The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

VOLUME XII

JANUARY-DECEMBER

1902

SAN FRANCISCO, CALIFORNIA

The Risdon Water Wheels at Colgate

FEB 28 1902

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

Price of this issue 10 cents

VOL. XII.—No. 1. SAN FRANCISCO, CAL., JANUARY, 1902. YEARLY SUBSCRIPTION, $1.00 SINGLE COPIES, - VARIABLE

1889 PARIS EXPOSITION MEDAL FOR RUBBER INSULATION

OKONITE TRADE MARK.

1893 WORLD'S FAIR MEDAL FOR RUBBER INSULATION

SOLE MANUFACTURERS OF

OKONITE TAPE : MANSON TAPE

CANDEE WEATHER-PROOF WIRES

THE OKONITE COMPANY, Ltd.,

Willard H. Candee, H. Durant Cheever } Managers
Geo. T. Manson, General Superintendent
W. H. Hodgins, Secretary

253 Broadway, NEW YORK.

WESTON ILLUMINATED DIAL STATION INSTRUMENTS

These instruments are based upon the same general principle and are just as accurate as our regular Standard Portable Direct Current Voltmeters and Ammeters, but are much larger and the working parts are inclosed in a neatly designed dust-proof cast iron case which effectually shields the instrument from disturbing influences of external magnetic fields.

WESTON ELECTRICAL INSTRUMENT CO.

Waverly Park, Essex County, N. J., U. S. A.

NEW YORK BOSTON PHILADELPHIA PITTSBURG CHICAGO SAN FRANCISCO

STANDARD FIBER PAPER RUBBER CABLES UNDERGROUND TELEPHONE ELECTRIC LIGHT AND POWER CABLES CABLE HIGH GRADE RUBBER AND WEATHER PROOF WIRES CO.

Inquire about the work we have done, and the thousands of miles of Feeder Cables (aerial and underground) we have furnished and installed for electric railway and other companies. The replies will interest you.

Factories at Perth Amboy, N. J., Pittsburg, Pa., and Oakland, Cal.

Pacific Coast Sales Agent, CHAS. F. SLOANE. Room 1, Second Floor, MILLS BUILDING, San Francisco

General. . Electric. . Company

Schenectady, N. Y.

Manufacturers of the . . .

STANDARD ELECTRICAL APPARATUS OF THE WORLD.

Claus Spreckels Building, SAN FRANCISCO, CAL. Worcester Building, PORTLAND, OR.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

Northern Electrical Manufacturing Company

MADISON, WIS.

NORTHERN GENERATORS are RUGGED and SUBSTANTIAL but Clean Cut and Symmetrical

For Belt or Engine Drive

Designed and built with the idea that the purchaser wants a machine which will live as long as he does. In truth, we think some of these self-same machines will be passed on to sons and grandsons. Northern motors are built on the same principle. If you would like a little more light on the matter write for Bulletin No. 926.

We have made some of the largest installations for complete electric drives in America, and challenge a comparison of economical working.

We build all sizes of generators and motors for either alternating or direct current.

JNO. MARTIN & CO. Pacific Coast Agents

Pioneer Bldg, Seattle, Wash. 31-33 New Montgomery St., San Francisco, Cal.

IDEAL ENGINES OF ALL TYPES

ARE CONSTRUCTED WITH THE

IDEAL SELF-OILING SYSTEM

ALBERT L. IDE, PATENTS

The bearings of Ideal Engines run on a clear film of oil, hence remarkably low friction

Celebrated as the Most Perfect and Reliable Method of Automatic Lubrication Known

CHAS. C. MOORE & CO.

Engineers and Contractors for

Complete Power Plants

Branch Offices: LOS ANGELES SEATTLE NEW YORK

Main Office: 32 FIRST STREET San Francisco, Cal.

Best by Test!

TUTTHILL WATER WHEELS

Adaptable to All Speeds and Heads

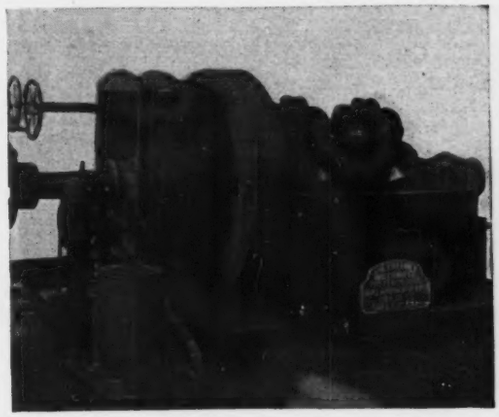
High in Efficiency! Low in Cost!

Write for our 1900 Water Wheel Catalogue. It is replete with hydraulic data and—gratis.

OAKLAND IRON WORKS

Business Office: 330 Market Street, San Francisco. 'Phone, Main 1007.

Works—Second and Jefferson Streets, Oakland. 'Phone, Main 342.



GEORGE E. CARTER & CO.

Room 28, Crocker Building SAN FRANCISCO

Telephone Bush 481

Quotations Furnished in Lots and Sizes to Suit Demands.

SQUARE SAWN REDWOOD ROUND RED CEDAR Poles and Pine Cross Arms

PROFESSIONAL.

EDWARD S. COBB

Designing and Consulting

MECHANICAL AND HYDRAULIC ENGINEER

Plans, Estimates, Specifications, Tests, Supervision of Construction

Room 223, Homer Laughlin Bldg., 315 South Broadway, Los Angeles, Cal.

ROBERT McF. DOBLE

Mechanical and Electrical Engineer

Consultation Supervision Constructing

MILLS BUILDING SAN FRANCISCO

LEON M. HALL

CONSULTING ENGINEER IN MECHANICS, ELECTRICITY, MINING.

331 Pine Street San Francisco

Telephone, MAIN 989

ENGINEERING OFFICES

331 Pine Street, : San Francisco, Cal.

E. H. Benjamin, Mining Engineer

A. M. Hunt, Mechanical and Hydraulic Engineer

Wynn Meredith, Electrical Engineer

C. L. Cory, Electrical and Mechanical Engineer

Wyatt H. Allen, Electrical Engineer.

Expert Examinations: Advisory Reports: Construction Supervision

Telephone, Main 1870. Cable address, "Edben."

FRANK E. SMITH

Consulting and Supervising Electrical Engineer

418 Eugenia Ave. ('Phone, Blue 751) San Francisco

FRANK H. BATES

CHEMICAL and GAS ENGINEER

With Chas. C. Moore & Co., 32 First St., San Francisco

Westinghouse Gas and Oil Engines installed for use with natural, illuminating, and producer gas, gasoline, distillate or crude oils, and in single units as large as 750 horsepower.

Contracts taken for complete Gas Producer and Engine Installations for electric light or other service, with absolute guarantees as to regulation, economy and durability.

EDWARD P. BURCH

Consulting Electrical Engineer

1210 Guaranty Building, Minneapolis, Minn.

FRANK P. MEDINA

Attorney-at-Law

Counselor in Causes Involving the Law of Electricity

Electrical Patents a Specialty

With Smith & Osborn Patent Attorneys 212 Sansome St. San Francisco, Cal.

"Chloride Accumulators"

Send for Price List "A," 3d Edition.

Sales Offices

Philadelphia New York Boston Chicago Baltimore Cleveland St. Louis Detroit SAN FRANCISCO: Nevada Block

Installations aggregating 225,000 K. W. hours are the most convincing and powerful arguments that can be offered as to their economy and efficiency.

THE ELECTRIC STORAGE BATTERY CO.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

NATIONAL TUBE COMPANY,

MANUFACTURERS OF

High-Pressure Pipe Lines.

We manufacture lap-welded pipe and receivers for power lines up to 30 inches diameter, with lead joints, expanded and riveted joints, cast-iron or rolled-steel flange joints, or solid welded flange joints.

We also manufacture a full line of welded and seamless tubular goods.

LAP-WELDED PIPE only is used for extreme pressures. Among those using our pipe lines for this purpose may be mentioned the following California companies:

San Joaquin Electric Co.	20-inch	pipe,	1411	head,	612	lbs.	pressure.
Blue Lakes Water Co.	22	"	"	1040	"	451	"	"
Mt. Whitney Power Co.	20	"	"	1300	"	574	"	"
Standard Electric Co. of California ...	30	"	"	1485	"	640	"	"

California Sales Office, No. 420 California Street, San Francisco, Cal.

IMPERIAL PORCELAIN

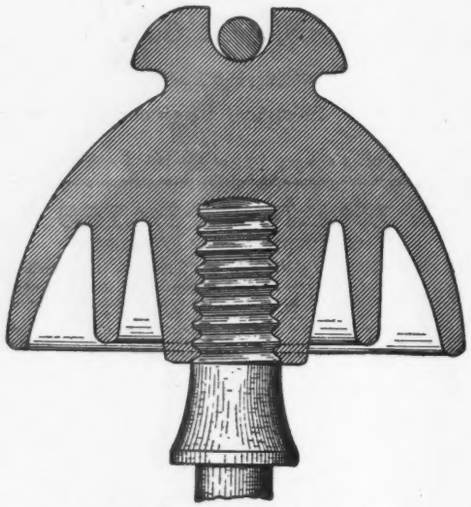
Manufactured by Imperial Porcelain Works.

TRADE MARK

IMPERIAL PORCELAIN

HIGH-POTENTIAL INSULATORS

These Insulators are in exclusive use on such important power transmission lines as:



Eight Different Types—All Voltages

SOUTHERN CALIFORNIA POWER CO., - - - *Redlands to Los Angeles*

SNOQUALMIE FALLS POWER CO., - - - - - - *Snoqualmie Falls to Seattle and Tacoma*

WEST KOOTENAY POWER AND LIGHT CO., - - - - - - *Bonnington Falls to Rossland*

NIAGARA FALLS POWER CO., - - - - - - *Niagara Falls to Buffalo*

HUDSON RIVER POWER TRANSMISSION CO., - - - - - - *Mechanicville to Schenectaay*

and many others.

Address all correspondence to

C. T. Knowles.

General Sales Agent

7 Arch Street, BOSTON, MASS.

$1.00 per year

Order now, for no extra copies will be printed

Each and Every Issue of

"THE JOURNAL"

is highly illustrated and its contents are of unusual merit. It is, in fact, an altogether invaluable contribution to the literature of transmission engineering. And, by the way, why don't you subscribe? : : : : :

THE JOURNAL OF ELECTRICITY, POWER AND GAS

LIGHTEN THE "WHITE MAN'S BURDEN"

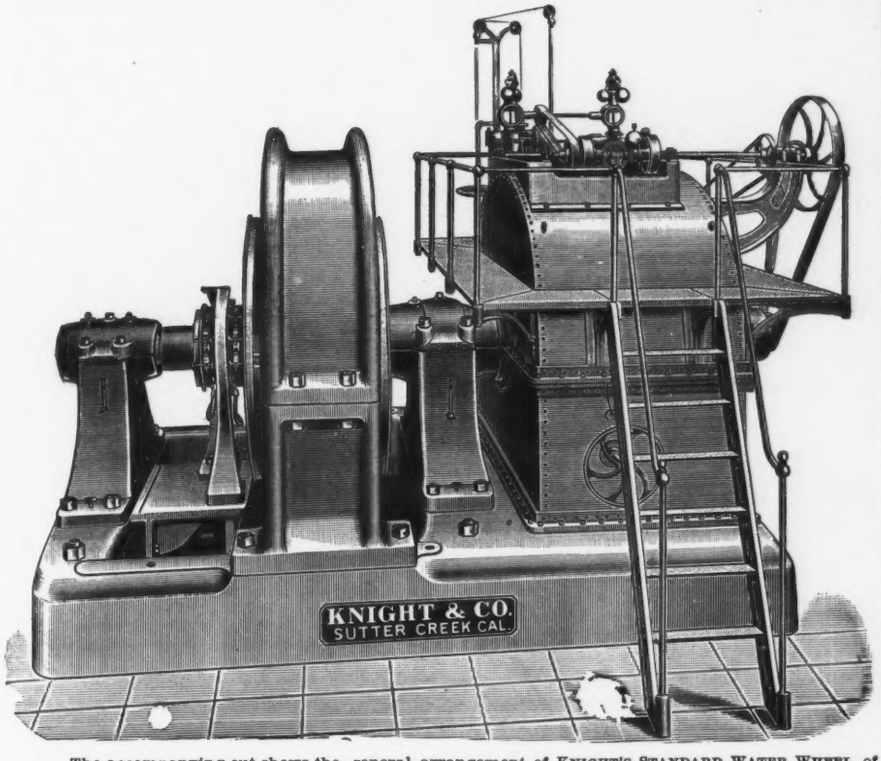
The fireman will rejoice and it won't matter much to the coal man if you cut him 5 or 10 % now that business is good.

(Clean Boilers.) Try it. DEARBORN FEED WATER TREATMENT

SEND A GALLON JUG OF WATER FOR ANALYSIS.

Dearborn Drug and Chemical Works, WM. H. EDGAR, President. **29-33 Rialto Bldg., Chicago, Ill.**

KNIGHT'S WATER WHEEL



The accompanying cut shows the general arrangement of KNIGHT'S STANDARD WATER WHEEL, of which there are HUNDREDS IN USE in different States of the Union. These wheels are made from 2 to 6 feet in diameter, from 10 to 1000 horse power. and adapted to all heads and purposes Wheels inclosed in iron cases from 6 to 24 inches. Wheels for electrical power can be furnished with or without Governors. Highest regulation guaranteed. Address all communications to

For full particulars send for descriptive catalogue.

KNIGHT & CO., Sutter Creek, Cal.

ADVERTISERS' INDEX.

	PAGE
Abner Doble Company	xiii
Bates, F. H.	iii
Benjamin, Edward H	iii
Bullock Electric Manufacturing Co	vi
Burch, Edward P	iii
Byron Jackson Machine Works	vii
California Electrical Works	vii
Carter, & Co., George	iii
Century Electric Co.	v
Cobb, Edward S	iii
Cole, John R	vi
Cory, C. L	iii
Crocker Wheeler Co	vi
Crosscup, I. O	vii
Crouse-Hinds Electric Co	xv
Dearborn Drug and Chemical Works	v
Doble, Robert McF	iii
Electrical Engineering Company	xi
Electric Storage Battery Co	iii
General Electric Company	i
Hall, Leon M	iii
Hardwood Planing Mill Co	x
Heald's School of Engineering	v
Hunt, A. M	iii
Ide & Sons, A. L	iv
Joseph Dixon Crucible Co	x
Knight & Co.	v
Knowles, C. S	iv
Locke, Fred M	vii
Lombard Governor Co	ix
Martin & Co., Jno	vii, viii, xvi
Medina, Frank P	iii
Meredith, Wynn	iii
Moore & Co., Chas. C	iii
National Tube Company	iv
New York Insulated Wire Co., The	x
New York Lubricating Oil Co	vi
Northern Electrical Mfg. Co	ii
Oakland Iron Works	iii
Okonite Company, Ltd., The	i
Pacific Electrical Works	ix
Paraffine Paint Company, The	vii
Pass & Seymour	xv
Pelton Water Wheel Company	xii
Pittsburgh Reduction Company	viii
Ridley, A. E. Brooke	vi
Sloane, Chas. F	i, xi, xv
Smith, F. E	iii
Standard Underground Cable Co	i
Stanley Electric Manufacturing Co.	xvi
Stanley Instrument Co	v
Union Lumber Company	v
Van der Naillen School of Electricity	v
Westinghouse, Church, Kerr & Co	viii
Westinghouse Electric & Manufacturing Co	viii
Westinghouse Machine Co	viii
Weston Electrical Instrument Co	i
Worthington, Henry R.	xiv

REDWOOD POLES

For TELEGRAPH
TELEPHONE
ELECTRIC LIGHT
POWER PLANTS

In lots and sizes to suit at short notice.

Union Lumber Company

TELEPHONE, "MAIN 324"

Rooms 206-207, Crocker Building, San Francisco

CENTURY ELECTRIC CO.

ENGINEERS
AND
CONTRACTORS

18 Second St., - SAN FRANCISCO
Telephone, BUSH 352

Pacific Coast Agents for
ELECTRICAL INSULATING CONDUIT CO.,
Write for information and prices

Stanley A. C. Wattmeters

Permanent Accuracy Guaranteed

STANLEY INSTRUMENT COMPANY

San Francisco, 31-33 New Montgomery St.
SEATTLE, WASH., Pioneer Building
New York, 146 Broadway.

?

Do you read THE JOURNAL OF ELECTRICITY, POWER AND GAS? If you don't, now is the time to subscribe. $1. 536 Clay Street, San Francisco, Cal.

—SCHOOL OF—
PRACTICAL ENGINEERING
(ELECTRICAL, CIVIL, MINING AND MECHANICAL)

Surveying, Drawing, Architecture and Assaying.

113 Fulton St., : : San Francisco
(One block above New City Hall)

A. VAN DER NAILLEN, President
Send for circulars Established 1864

HEALD'S

BUSINESS COLLEGE
—AND—
SCHOOL OF ENGINEERING

Electrical Engineering Department
ORION BROOKS, Instructor.

Mining and Assaying Department
G. W. MILES, M. S., Instructor.

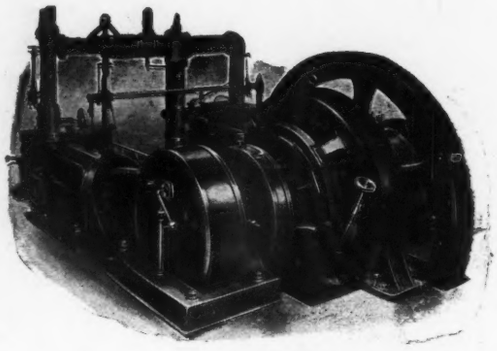
24 Post Street, San Francisco.

Crocker-Wheeler Company

Manufacturers and Electrical Engineers

Branch Offices and Representatives in all Principal Cities

The design of the CROCKER-WHEELER Engine Type Generator is such as to meet the most approved requirements, and to comply with the standards adopted in the best and most recent practice. The strength and endurance, low current density in windings, commutator brushes and other conducting parts; ample cooling surface and adequate means of ventilation; a substantially flat efficiency curve and a nearly straight compounding curve, low armature reaction and no variation of brush lead are some of the features.



Railway Generator

The iron and steel used for the field and armature are selected with special reference to their magnetic qualities; the other materials are selected with reference to their suitability for duty. In every respect the workmanship is of the highest class.

Main Office and Works: Ampere, N. J.

San Francisco Office: Abner Doble & Co., Managers.

Denver Office: 624 Cooper Building.

BULLOCK ELECTRIC MFG. CO.
Cincinnati, U. S. A.

WAGNER ELECTRIC MFG. CO.
St. Louis, U. S. A.

Direct and Alternating Current Equipments for Electric Light and Power . . . .

287

The same sun shines for all—so does an advertisement in this publication. Others have felt the warm rays from its columns—why not you?

New York Lubricating Oil Company Manufacturers and dealers in HIGH-GRADE LUBRICANTS

MARINE, ENGINE, RAILROAD, CYLINDER and the . . . . . **I. S. C. TRANSFORMER OIL**

530 California Street, SAN FRANCISCO (Rooms 3 and 5) 35 Water St., New York

A. E. BROOKE RIDLEY ELECTRICAL ENGINEER and CONTRACTOR. . . .

597-599A Parrott Building
10 Front Street
San Francisco, Cal.

POWER TRANSMISSION

Managers have no line troubles when using

Locke Insulators

VICTOR TYPE.....

Line Pressure 60,000 Volts.

Tested to 120,000 Volts.

Adopted by

STANDARD ELECTRIC COMPANY Of California.

BAY COUNTIES POWER COMPANY.

On Longest Power Transmission Lines in the World

400,000 LOCKE INSULATORS in use on the Pacific Coast, Operating on Line Pressures up to 60,000 Volts. . . . . .

JNO. MARTIN & CO.

PACIFIC COAST AGENTS

SEATTLE, WASH.: Pioneer Building.

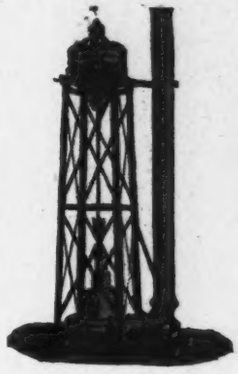
SAN FRANCISCO: 31-33 New Montgomery Street.

BYRON JACKSON MACHINE WORKS

Hydraulic Engineers

411 MARKET ST., SAN FRANCISCO, CAL.

Our Multiple Compound Centrifugal Pumps are Unequalled



Our Self-oiling Bell Ends For Vertical Electric Motors Insure success

MANUFACTURERS OF

High Head Direct Connected High Speed

ELECTRICALLY DRIVEN PUMPING MACHINERY

Branch Office—201 North Main St.—Los Angeles, Cal.

San Francisco, Cal., October 19, 1901.

We wish to announce the removal of our offices, warerooms and factory from 409 Market street to our new building, 547 Mission street, between First and Second.

Our new quarters were designed especially for our use and we have unrivaled facilities for looking after the supply trade, wiring, manufacturing and repairs.

Our stock has been largely increased to meet the rapid growth of the business and we have enlarged our factory and repair department, so that we can handle all classes of work.

We shall be pleased to have you call and inspect our new premises.

Telephone Private Exchange 144

California Electrical Works.

CROSSCUP'S XXX BOILER COMPOUND

Is guaranteed

To remove and prevent scale;
To stop and prevent pitting and corrosion;
To stop priming, and keep boilers in first-class condition for less cost per horsepower than any other compound on the market.

All orders promptly filled by

I. O. CROSSCUP,

530 California St., (Room 32) SAN FRANCISCO

In cases of Insulation

Use **P & B** Paint
Building Paper or
Ready Roofing

These articles are made to withstand the injurious effects of water, heat, gases, vermin, rats and mice. They are non-conductors and can be used advantageously about electrical works or construction of all kinds. *Write for booklets—address dept. J.*

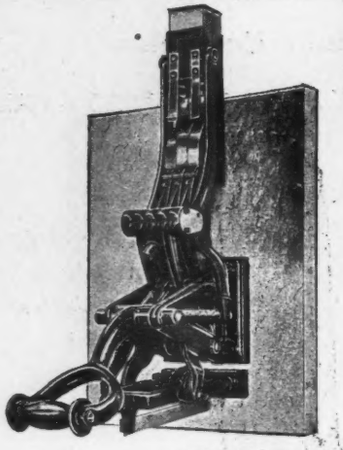
PARAFFINE PAINT COMPANY
116 Battery Street : : San Francisco

Westinghouse

Automatic

Circuit Breakers

For Direct and Alternating Currents



Open the circuit under any conditions of overload or short circuit and without damage to copper contacts . . . .

Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Sales Offices: All Large Cities.

Westinghouse, Church, Kerr & Co.,
New York, Chicago, Boston—ENGINEERS—Pittsburg, Philadelphia, Detroit

The Westinghouse Machine Co.,
Pittsburg—Designers and Builders—Chicago
Gas and Steam Engines, Mechanical Stokers, Steam Turbines, Etc., Etc.

Write nearest office of Westinghouse, Church, Kerr & Co.

Aluminum Railway Feeders

ALUMINUM feeders are less than one-half the weight of copper feeders and are of equal conductivity and strength.

Joints of aluminum feeders can be easily, cheaply and satisfactorily made.

If wire or cable is required to be insulated, high-grade insulation is guaranteed.

Price-list with full information furnished on application.

The Pittsburgh Reduction Co.

PITTSBURGH, PA.

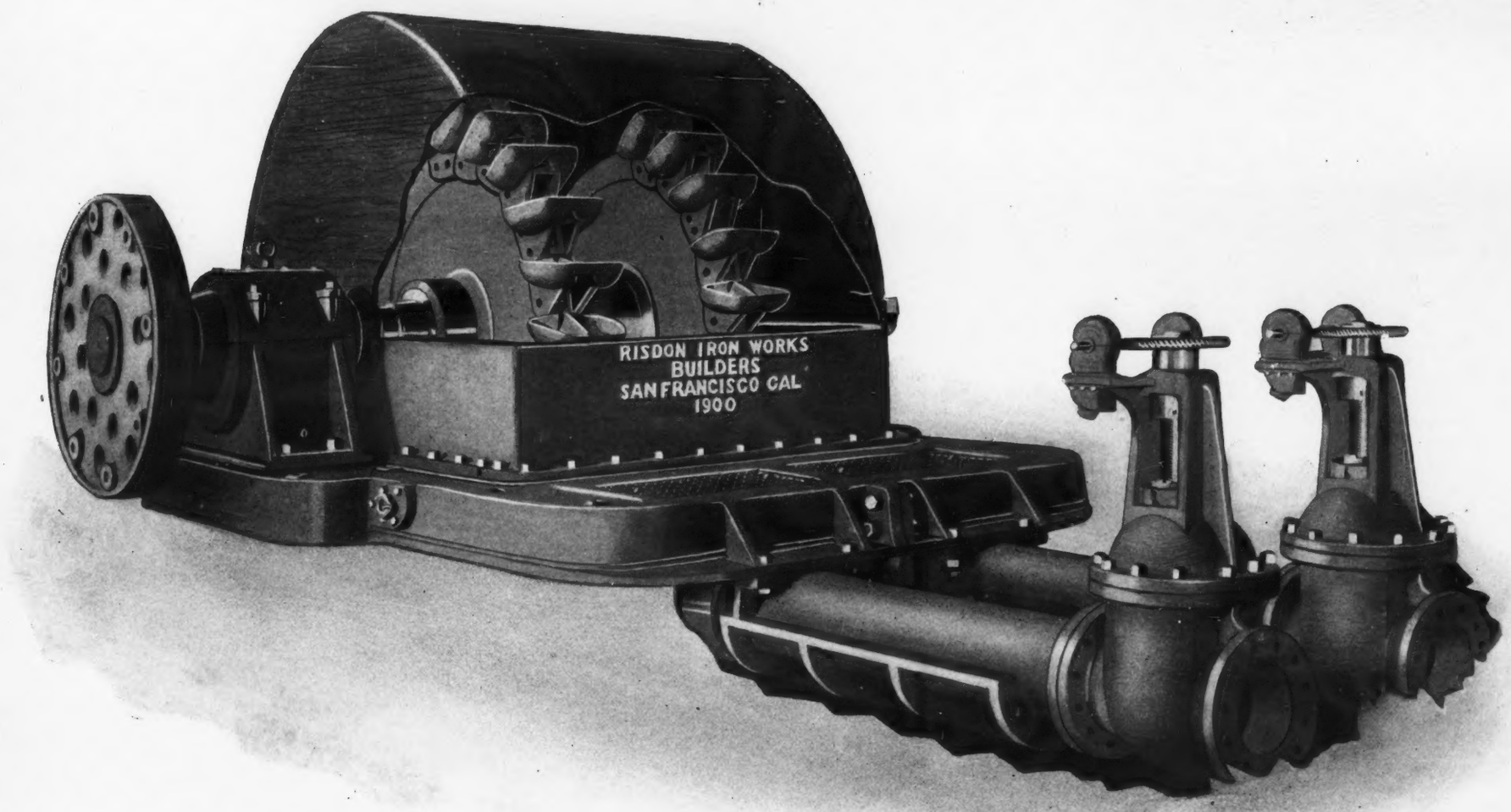
PACIFIC COAST AGENTS:

JNO. MARTIN & CO.

SAN FRANCISCO, CAL.: 31-33 New Montgomery St.

SEATTLE, WASH.: Pioneer Building

Power-Transmission, Telephone and Telegraph Wire



ONE OF THE THREE 3000-HORSEPOWER RISDON WATER WHEEL SETS AT THE COLGATE POWER HOUSE OF THE BAY COUNTIES POWER COMPANY.

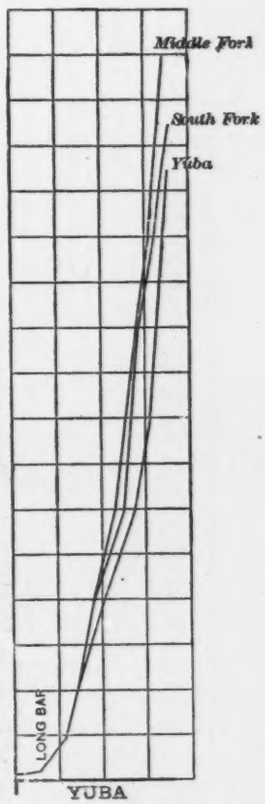
THE JOURNAL OF ELECTRICITY, POWER AND GAS.

Devoted to the Conversion Transmission and Distribution of Energy.

VOLUME XII. SAN FRANCISCO, JANUARY, 1902. NUMBER 1

The Hydraulic Equipment of the Colgate Power House.

IF ONE examines the characteristics of the rivers of America, especially as presented in a publication of the Department of the Interior,* he will be impressed with the fact that while the great majority of rivers of the country have generally low and comparatively flat profiles, those of California and Colorado are noteworthy in that the difference in elevation between their sources and their mouths is very great despite the comparative shortness of their lengths. The difference in elevation between the source and mouth of the Mississippi river, for instance, is scarcely 1500 feet, while its length is nearly 2300 miles; the Ohio river drops a little over 700 feet in its length of not quite 1000 miles; the mountains of New England give the Connecticut river a drop of 2000 feet in 375 miles, the Kennebeck river, which turns more spindles than any other source of power in America, drops 1000 feet in less than 150 miles. These are all elevations which are approached, if not exceeded, by the penstocks of many California power transmission plants.



PROFILE OF THE YUBA RIVER.
Vertical scale, 1 inch equals 2000 feet.
Horizontal scale, 1 inch equals 100 miles.

Again, if the source of the Hudson be considered as Lake Tear of the Clouds, the altitude of the Adirondacks gives it a drop of 4300 feet in its length of about 300 miles; the Arkansas river rises at the respectable altitude of 10,400 feet and is 1500 miles long; Three Forks, the head of the Missouri river, is at an elevation of some 4000 feet, the length of the river being 2340 miles, and the Rio Grande rises at 12,000 feet and flows along a stretch of nearly 1800 miles before reaching the Gulf of Mexico. It should be noted that with the possible exception of the Hudson, these rivers flow hundreds and hundreds of miles before they have attained a fall of several thousand feet.

But as the streams of Colorado and California are reached these conditions undergo a marked change, indeed the nearest approach to the profiles of the great rivers of the East is found in the Columbia, which rises at an altitude of over 3600 feet and flows into the Pacific through a length of 1100 miles. In comparison with this consider a few rivers of California: the Cosumnes rises at an altitude of 7500 feet and has a length of but 93 miles; the Yuba has a drop of 6700 feet in 90 miles; the Feather, 4678 feet in 136 miles; the American 8500 feet in 118 miles; the Calavaras, 1000 feet in 68 miles; the Stanislaus, 8000 feet in 113 miles; the Tuolumne, 8000 feet in 155 miles; and the Sacramento, 7000 feet in 400 miles. Colorado rivers are very similar to those of California. For instance, the Lake Fork of the Gunnison drops 13,200 feet in 59 miles and the Roaring Fork drops 11,676 feet in 64 miles.

Nature, beneficent and ever-impartial, seems to have compensated for the lack of great volume of water in these western streams by giving it extraordinarily high and easily developed head, so that many of these smaller rivers are as rich in mechanical energy as are those Eastern courses, which carry enormous volumes of water at low head.

*Water Supply and Irrigation Paper No. 44 of the United States Geological Survey on "Profiles of Rivers in the United states," by Henry Gannett.

No other cause than that implied in a recital of this situation can be assigned for the total abandonment of the turbine of the East and the development of a water wheel upon such radically different lines as are embodied in the tangential water wheel of California, for obviously it is impracticable to utilize turbines in the economical development of power from water at high head and consequently high velocity, as it is impossible to adapt the Rodney smooth bores to the high pressure and high velocity ordnance work today. The electrical transmission of power has been, in a great measure, responsible for the marked improvement which has taken place in the performance of these tangential water wheels, just as a decade ago the steam engine began to undergo changes for the better in response to the demand of the incandescent lighting dynamo that the prime mover for driving it should be of the highest attainable perfection in efficiency and speed regulation. As a result, water wheels of this type have been brought to such a high plane of efficiency in operation and in speed regulation that now they are perhaps as near perfect as it is possible for human ingenuity to make any prime mover.—THE EDITOR.

THE RISDON WHEELS AT COLGATE POWER HOUSE.

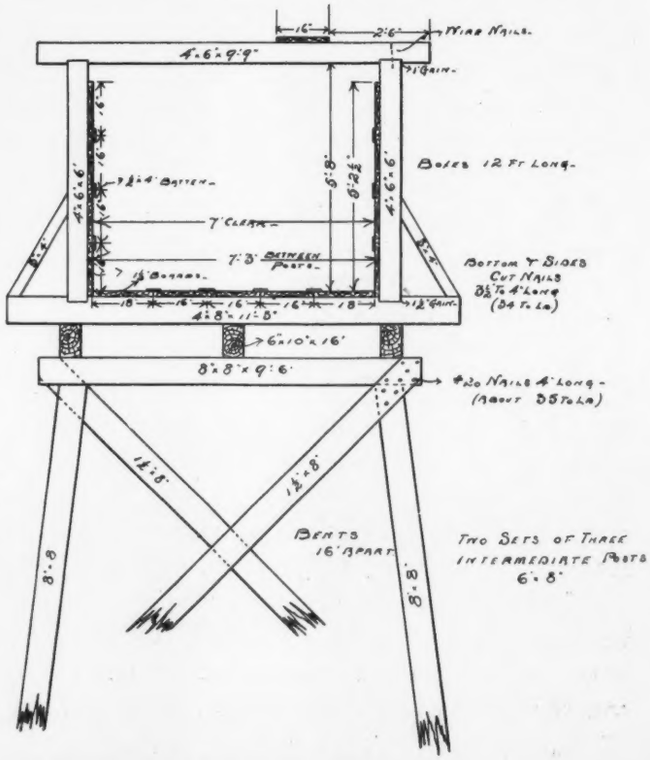
BY THOS. J. BARBOUR.

IN point of interest, a description of the hydraulic equipment of a great power house of one of the most noteworthy electrical transmission systems in the world must largely center in the water wheels and governors, in view of which but passing reference need be made to other hydraulic features of the installation, although their importance is by no means disparaged. It is suggested, then, that this article be regarded as supplemental to the popular description of the system of the Bay Counties Power Company which has appeared in these columns heretofore.*

WITHIN THE BAY COUNTIES FLUME DURING CONSTRUCTION.

The watershed of the Yuba rivers is characterized by its high altitude, its ruggedness and its heavy precipitation (for California) which averages fifty-five inches of rainfall, with a minimum of forty inches. The profile of the Yubas appears in the engraving on the preceeding page, the horizontal scale being plotted 100 miles to the inch and the vertical scale being 2000 feet to the inch according to the standard of the United States Geological Survey.

Water for the operation of the Colgate power house is taken from the main or North Yuba, which has a true watershed of 120 square miles above the dam, and is carried thence a distance of 7.6 miles through a flume to the penstock above the power house, whence it is delivered to the wheels through five independent pipe lines supplying two receivers. The flume, which has a nominal capacity of 20,000 miners inches, is built of lumber cut in a mountain forest some ten miles above the dam. In all 7,200,000 feet of lumber was used in the construction of the main flume. The underpinning and all superstructure is of red spruce, the sills are of heart cedar, the posts and caps are of yellow pine, the boards are of yellow and sugar pine and the battens are of sugar pine. The principal dimensions of the flume and its carrying capacities at different depths of water are presented in the accompanying drawings and table respectively. Its grade is 12.8 feet per mile.



DETAIL OF THE BAY COUNTIES FLUME.

*THE JOURNAL, Volume XI, page 145 *et. seq.*, July, 1901.

A CURVE IN THE LAKE FRANCIS PIPE LINE.

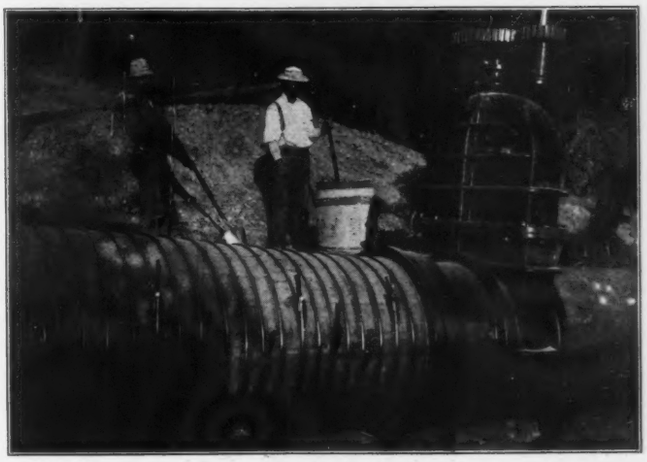
Lake Frances, the principal reservoir, is situated in the mountains about two and one-half miles above Colgate and nearly a mile below Dobbins' postoffice. It is supplied mainly by Dobbins' creek, which flows throughout the year, and when it is remembered that it is intended to be drawn upon only in case of accident to the flume, which is believed to be exceedingly remote, its capacity of 92,870,000 cubic feet is ample. Water is taken from Lake Frances first through a 36-inch wood stave pipe for a distance of 8502 feet, then through 936 feet of cast-iron pipe, and thence through a rapid flume for a distance of 2870 feet to the penstock. The staves used in this pipe are of clear redwood with a net thickness of $1\frac{9}{16}$ inches, the bolts therein being ½-inch in diameter with cold pressed thread and malleable iron shoes. In some places the stone pipe has been laid to a curvature as small as a radius of 150 feet, while the head to which it is subjected varies from 40 to 92 feet. The lower end of the stave pipe is joined to a 30-inch cast-iron pipe through the gate valve shown in the accompanying engraving, and the water is carried along this cast-iron pipe for a distance of 936 feet to the rapid flume, the purpose of which is to take the energy from the water while it is *en route*, thus delivering it to the penstock without heavy shock. The rapid flume has a gradient of 11 per cent., its depth is 12 inches, its width 3 feet and its capacity is approximately 5369 cubic feet per minute. The difference in elevation between Lake Frances and the penstock is 382 feet, and while it seems to be an apparent waste to destroy the energy due to this head, it is obvious that no real advantage would be gained through temporarily increasing the head of the main pipe lines by this amount because of the fact that the main wheels are not designed for the materially higher head that would result therefrom.

From the penstock are run five separate pipe lines down the hill to the power house 1625 feet distant. The pper two-fifths of the length of these pipe lines are of veted sheet steel, No. 12, 10 and 8 gauge, enumerated by respective sizes from the top. To be exact, the total length of the riveted steel pipe is 680 feet, and that of the lower portion, which is entirely of cast-iron with lead joints caulked, is, therefore, 945 feet. The upper lengths of the cast-iron pipe have walls 1 inch in thickness, which is increased to 1½ inches in the bottom lengths, the respective 12-foot lengths of the pipe varying in weight from 3800 to 5400 pounds. The inside diameter

RATE OF FLOW IN BAY COUNTIES POWER COMPANY'S FLUME.

DEPTH	AREA SQ. FT.	WET PERIM.	R	C	V	MINER'S INCHES
6″	3.5	8.0′	0.4375	107	3.51	491
1′–0″	7.0	9.0	0.777	121	5.3	1,484
1′–6″	10.5	10.	1.05	127	6.46	2,713
2′–0″	14.0	11	1.272	132	7.378	4,131
2′–6″	17.5	12	1.458	135 17	8.08	5,656
3′–0″	21.0	13	1.615	136.2	8.58	7,207
3′–6″	24.5	14	1.75	139.	9.14	8,957
4′–0″	28.0	15	1.87	140.5	9.53	10,673
4′–6″	31.5	16	1.97	141.8	9.87	12,436
5′–0″	35.0	17	2.06	142 4	10.11	14,154
5′–6″	38.5	18	2.14	143	10.36	15,954

Calculated by Kutter's formula. Flume, 7′ wide; grade, 13′ per mile.



THE STONE AND IRON PIPE LINES TO LAKE FRANCIS RUN THROUGH A 30-INCH GATE VALVE.

DOBBINS CREEK.

WHEEL DISCHARGE WITH AND WITHOUT LOAD RESPECTIVELY.

STONE PIPE LINE.

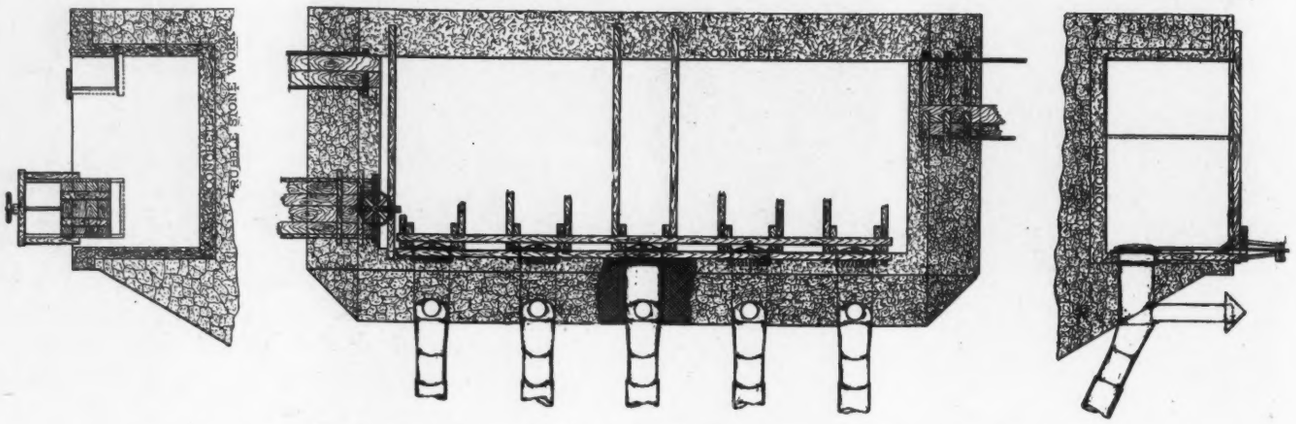
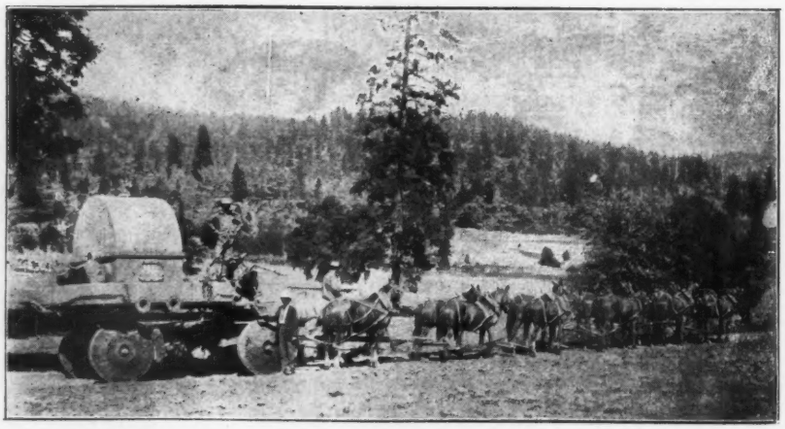


FIG. 2.---SECTIONS OF THE PENSTOCK AT THE HEAD OF THE FIVE PIPE LINES OF THE COLGATE POWER HOUSE.

of the pipe is 30 inches throughout, and the maximum static pressure to which its lowest length is subjected is 305 pounds per square inch, the head being 702 feet. The use of cast-iron pipe along sections of maximum pressure in pipe lines of this character was primarily due to the fact that it was impossible to purchase pipe of any other description at any price within the time specified for its delivery. In a way, then, the use of the pipe was an experiment, but experience has demonstrated that no error was made in its installation. Each length of pipe has been tested to a hydrostatic pressure of 500 pounds per square inch. Moreover, cast-iron pipe is non-collapsible, and its life is practically unlimited, for it rusts materially less than wrought-iron. The pipe is laid without angles or bends, and it is rendered absolutely rigid through the massive concrete anchorages that hold it fast to bedrock.

The maximum velocity of water in the pipe line is ten feet per second. At the penstock independent gates are provided for each pipe line, as are also independent air vents and slip joints. At the power house the pipe lines deliver water through individual 30-inch gates to two separate headers, so arranged as to allow either of the five pipes to be filled from the bottom. The two pipes lying toward the east enter the "East End" header, while the three remaining pipe lines enter the "West End" header. Fourteen-inch gate valves are provided for each main water wheel unit, but the exciter water wheels may be driven from either header.

A novel innovation, due to Mr. A. E. Roberts, is found in the control of the 12-inch gate valves that are placed in the 14-inch pipe lines running between the receiver and the nozzles. The pressure on the gate when the valve is closed is nearly 50,000 pounds, to open which by a hand mechanism geared down to give an easy leverage would consume much more time than necessary to protect the pipe line. The pressure of the water in the receiver is therefore employed to open its own way to the wheels by placing two small 6-inch water motors on each end of a worm spindle for driving a worm wheel that is fastened to the travelling nut which raises the gate stem. To insure easy running and to guard against sticking, the worm spindle is provided with ball thrust bearings and the nut of the valve stem runs between roller bearings. The water motors are placed on the worm spindle with buckets and nozzles facing opposite directions, so that when the water is turned on to one wheel it closes the valve, and when the water is on the other wheel the valve is opened. These little wheels make from 10,000 to 12,000 revolutions per minute and deliver in the neighborhood of four horsepower each, so it follows that the valve may be opened or closed by them very quickly. Moreover, as their action is gradual and properly timed, their use presents no danger of injuring the pipe line by water ramming.



QUEER CONVEYANCES BECAME FAMILIAR ON THE MOUNTAIN ROADS.

The history of the invention and development of tangential water wheels is clear, straightforward and indubitably authentic in so far as it accredits its inception and invention to Mr. Joseph Moore in 1874. Mr. Moore was then one of the owners and a director of the Risdon Iron Works, of San Francisco, and a brief review of the events leading up to the invention is of interest because of the controversy which has always existed upon the point. In March, 1874, Mr. G. Tiscornia, of San Andreas county, California, came to the office of the Risdon Iron Works, in San Francisco, and applied to Mr. Moore for information respecting a

water wheel to drive his quartz mill. Mr. Moore, after computing the amount of water and head available, found that there was not sufficient energy in the water power at hand to perform the required work with the hurdy-gurdy wheels then used, in view of which he suggested to Mr. Tiscornia that the buckets be changed in shape so as to gain reactive effects and avoid oblique impingement. Mr. Moore then stated to Mr. Tiscornia that he would submit a sketch of buckets which would give much better

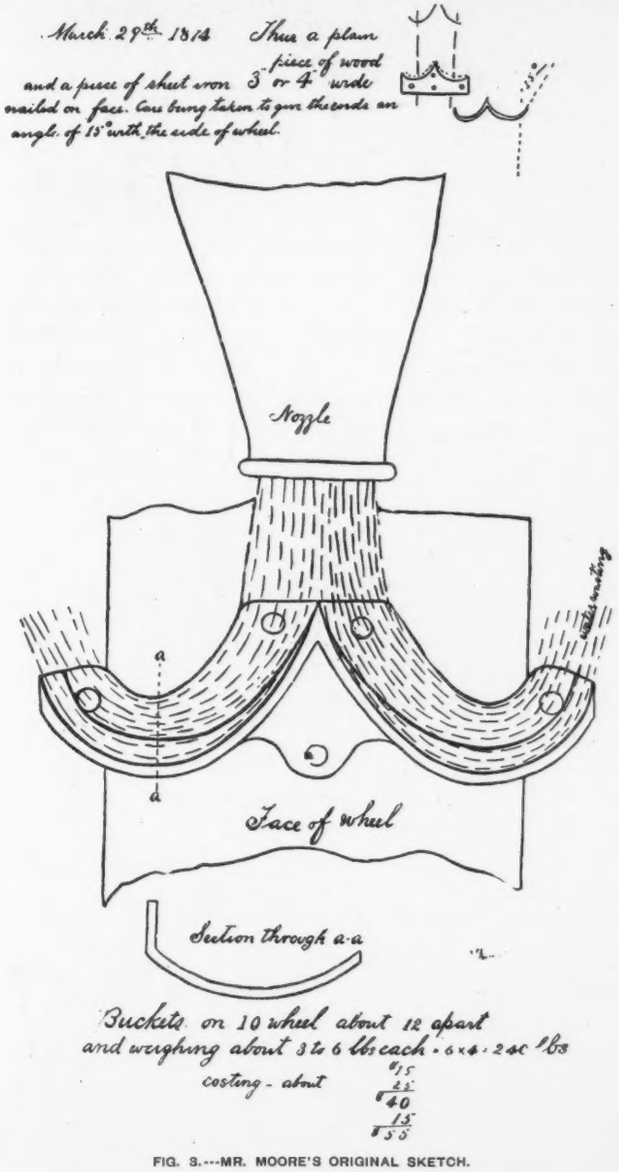

March 29th 1874
Thus a plain piece of wood 3" or 4" wide and a piece of sheet iron nailed on face. Care being taken to give the ends an angle of 15° with the side of wheel.
Nozzle
a
a
Face of wheel
Section through a-a
Buckets on 10 wheel about 12 apart and weighing about 3 to 6 lbs each - 6x4 - 24c lbs costing - about
$0.15
2.25
.40
.15
$3.55

FIG. 3.---MR. MOORE'S ORIGINAL SKETCH.

results and enable Tiscornia to drive his quartz mill with the water available.

Mr. Moore did as agreed, for on March 29, 1874, he wrote to Mr. Tiscornia enclosing therein the sketch, which is here reproduced from the records of the Risdon Iron Works as Figure 3. This was followed by other correspondence, all of which is preserved by the Risdon Iron Works, which embodied all the essential principles relating to the design of buckets for tangential water wheels. The two important principles expressed in these

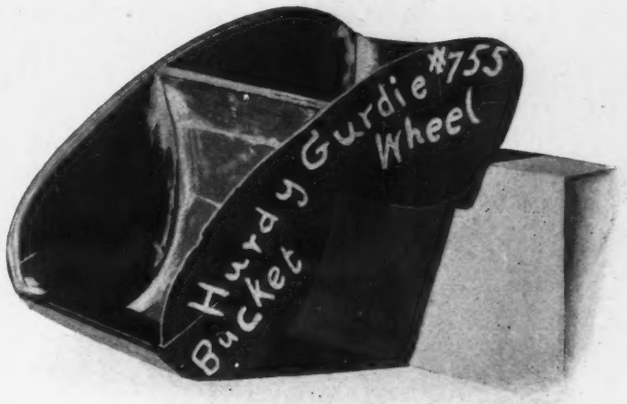


FIG. 4.---THE MOORE BUCKET, PATTERN OF 1874, IN PERSPECTIVE.

letters are that the jet of water should "enter the bucket without shock" and "leave without velocity," and the execution of these principles today form the bulwarks of success in tangential water wheel design.

These principles were fully embodied in a set of buckets made for Mr. Tiscornia in April, 1874, by the Risdon Iron Works None of the castings of these old buckets are in existence so far as it is known, but fortunately the pattern from which they were made is still in the posession of the Risdon Iron Works, and it is so full of interest that photographic reproductions of it are here given. Figures 4 and 5 are halftone engravings presenting the front and rear views respectively of this valued relic, while Figure 6 is a true transverse section made from templates fitted to the pattern, the scale being reduced by photography in exact proportion of the original size, which was 8 inches in width by 3½ inches in depth from the point of the wedge to the plane of the back of the bucket. This form of construction will at once be recognized as one which has since become known under a name different from that of its true inventor.

While the principles of the tangential water wheel, as established by Mr. Moore, have been neither modified nor changed in any way since their announcement by him over a quarter of a century ago, it has since been found that all buckets having the corresponding elements of the

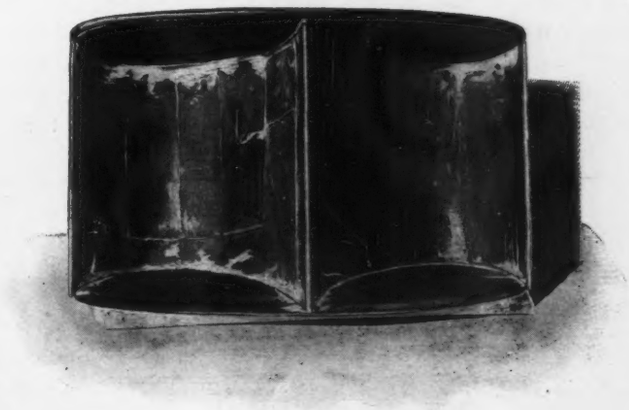


FIG 5 ---THE ORIGINAL PATTERN OF THE MOORE BUCKET OF 1874.

vanes of the two halves placed parallel with each other are open to the objection that the water discharging from the inner side of the vane is inclined inwardly from the usual tangential direction, as shown in Figure 7. This fault is entirely avoided in the present form of Risdon bucket, which is constructed with the corresponding

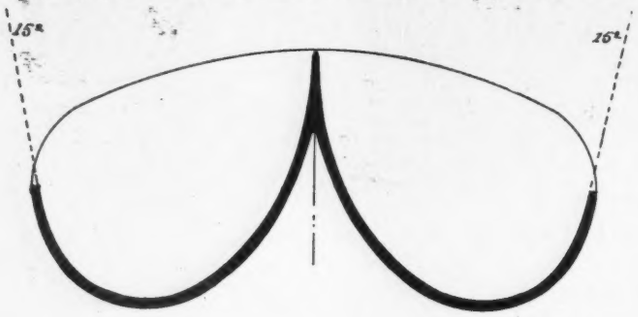


FIG. 6.---TRUE TRANSVERSE SECTION OF THE PATTERN FOR MR. MOORE'S ORIGINAL BUCKET.

elements of the vanes in the two halves of the bucket considerably inclined to each other at angle opening inwardly, as shown in Figure 8. By this construction the water discharged from the inner side of the vane is all deflected in a direction away from the path of the succeeding buckets far enough to clear them entirely, after the manner admirably shown in Figure 9.

These last two drawings illustrate practically the only improvements which have been made upon the principles set forth in Mr. Moore's original declaration, and, indeed, they should be regarded as mere refinements of his master conception. These two illustrations, moreover, may be regarded as setting forth the theory upon which the Risdon wheels at Colgate are based and operate.

Returning to the water wheel installation at Colgate, the water is thrown upon the wheel by a deflecting nozzle which is connected to the pipe by a ball and socket joint. The nozzle is provided with riffles cast on the inside to prevent the water from swirling as it approaches the discharge tip. That the riffles perform their work admirably is shown by the non-retouched photograph on page 12 which was taken by flash-light in the wheel pit. The discharge tip delivers a stream four inches in diameter which delivers a mechanical energy amounting to 1500 horse-power from the wheel. Deflecting nozzles are used as the best means of effecting the regulation of the power supplied by the wheels, and they possess the

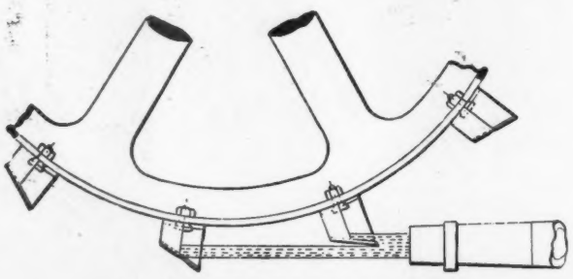


FIG. 7.---ANOTHER OF THE ORIGINAL SKETCHES.

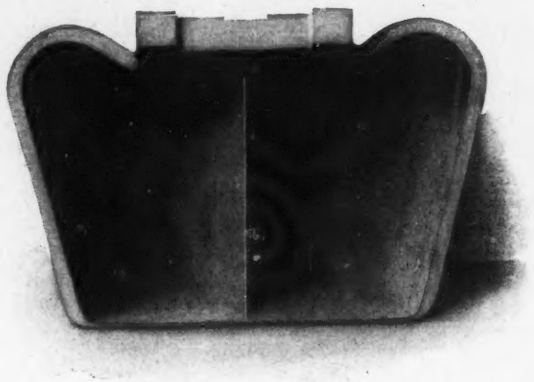


FIG. 8.---THE RISDON BUCKET OF TODAY.

further advantage that by their use the velocity of the water in the pipe line remains the same at all times, thus avoiding the violent shocks on the pipe which are caused by suddenly diminishing or checking the velocity of water in the pipe line. The trunnion pins in the ball and socket joint are of forged steel working in sockets laid with bronze bushings. As the pressure on each pin is about 30,000 pounds, they have to be very large, and in order to insure a permanently tight joint a large wearing surface on the pins is allowed so that each pin will

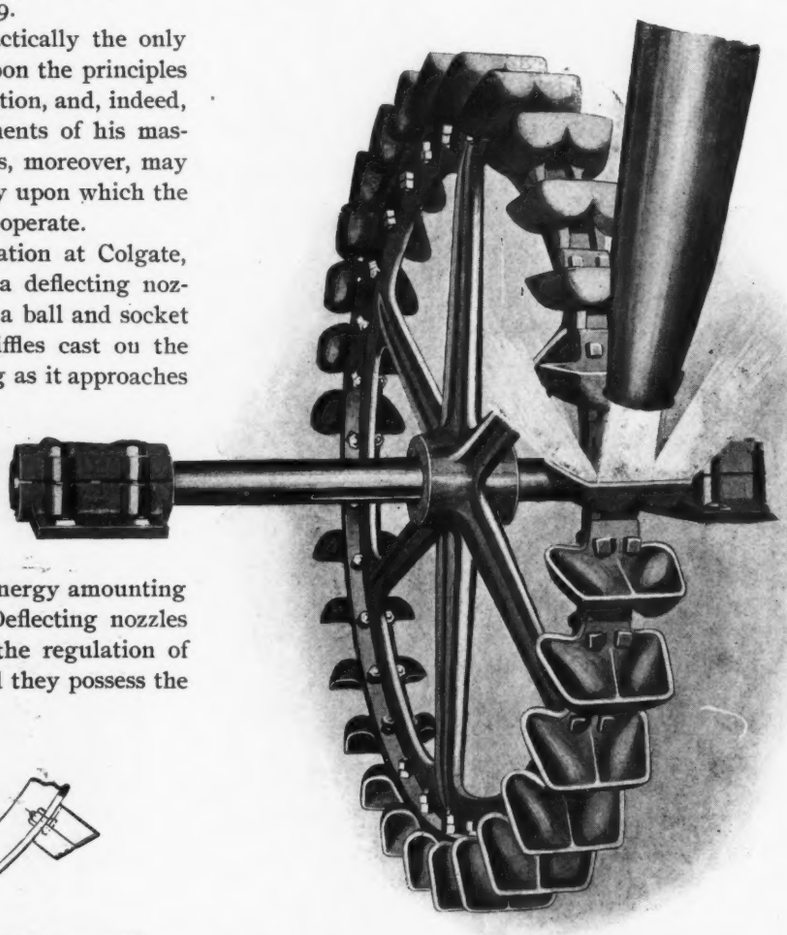
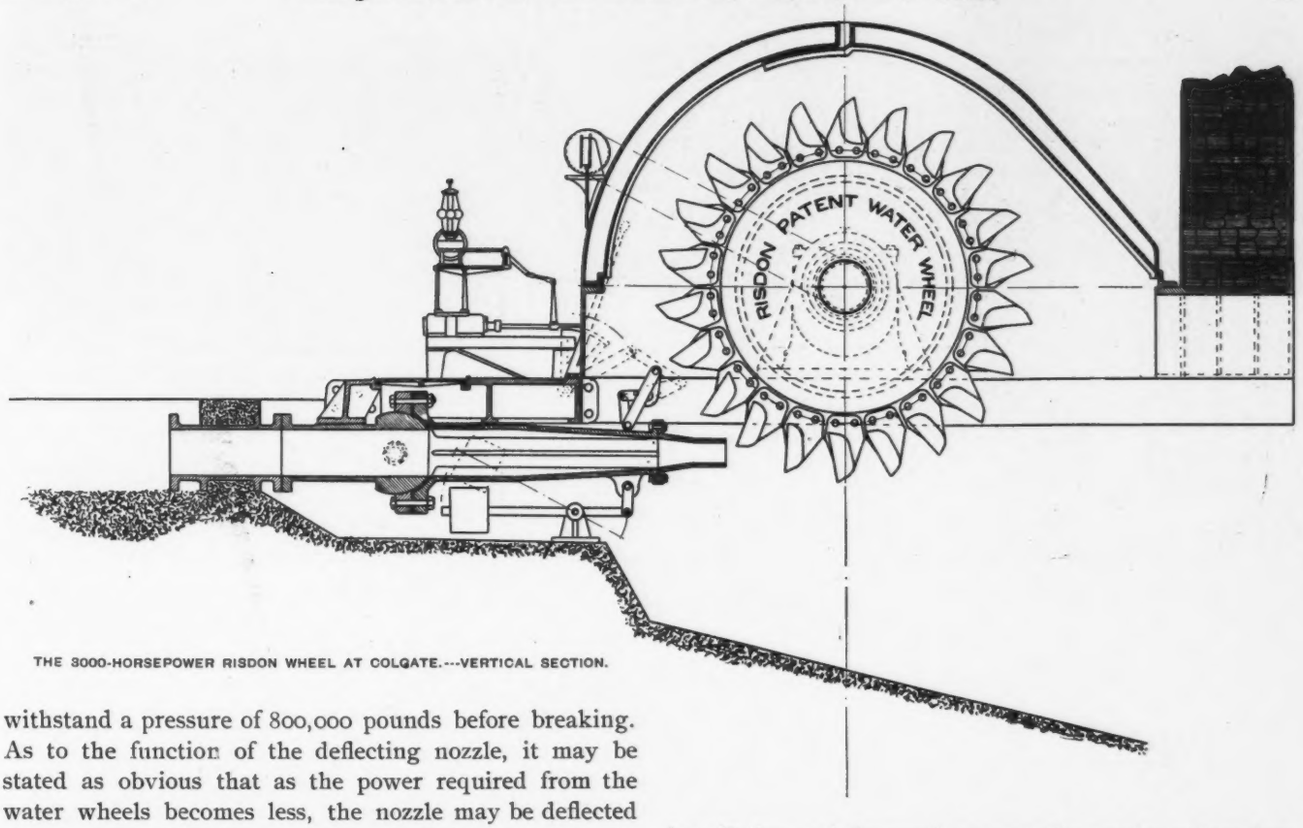


FIG. 9.---THE PERFECT CLEARANCE OF DISCHARGE CHARACTEIRZES THE RISDON BUCKET



THE 3000-HORSEPOWER RISDON WHEEL AT COLGATE.---VERTICAL SECTION.

withstand a pressure of 800,000 pounds before breaking. As to the function of the deflecting nozzle, it may be stated as obvious that as the power required from the water wheels becomes less, the nozzle may be deflected downwardly, throwing a part or all of the jet below the buckets of the wheel, according to the power required to drive the load at normal speed. The nozzles are actuated by Lombard water wheel governors, which will be the subject of special consideration further on.

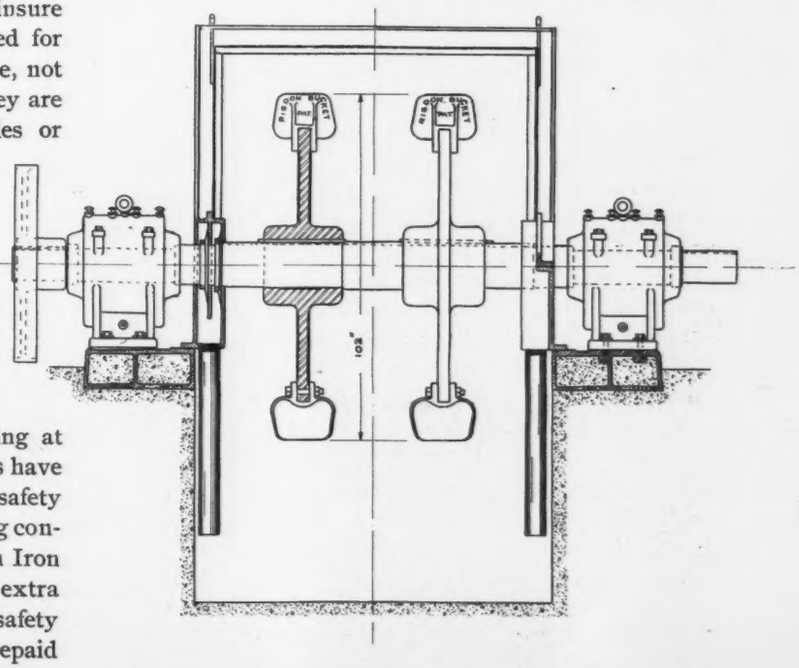
As to these wheels at Colgate, it may be said that both buckets and centers of wheels are made of the best quality of cast steel that can be obtained. Its unusual excellence is shown by the tests given in the table on page 12.

A special test is made of each lot of steel used in the manufacture of Risdon water wheels in order to insure that none but the very best of material shall be used for every piece. The castings of the wheels, therefore, not only show unusual strength and toughness, but they are perfectly smooth and entirely free from blow-holes or defects of any kind.

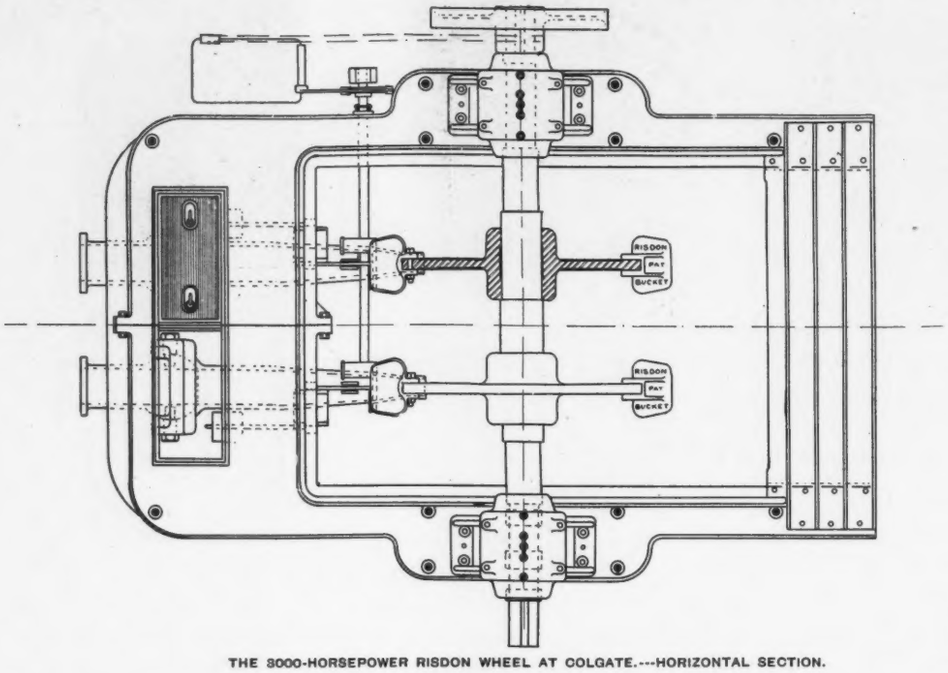
The wings of the buckets are milled out on a special Ingersoll slabbing machine and then driven on the edge of the turned disc. Holes are then drilled to template through the wings and disc and fitted with turned forged steel bolts driven in. The strain on one bolt may reach as high as 65,000 pounds, so they are made strong enough to stand 700,000 pounds without breaking. When the wheels are working at normal load these bolts have the excessive factor of safety of nearly sixty, it being considered by the Risdon Iron Works that the little extra for cost for excessive safety factors would be well repaid in the permanency of the installation and the small expense for repairs or loss from stoppages in the future.

DIAGRAM SHOWING THE INTERFERENCE OF THE DISCHARGE METER WITH THE FOLLOWING BUCKET, WHICH IS AVOIDED IN THE RISDON WATER WHEEL.

The discs are carefully bored and shrunk on a very heavy shaft and keyed on in the shop. The factor of safety of the shaft against the combined forces of twisting and bending, or against torque and weight, is over fifteen. The ring oiling, ball and socket, adjustable bearings are of the type of the Stanley Electric Manufacturing Company, to correspond with those of the generators. The bearings have large surface and are lined with



THE 3000-HORSEPOWER RISDON WHEEL AT COLGATE.---TRANSVERSE SECTION.



THE 3000-HORSEPOWER RISDON WHEEL AT COLGATE.---HORIZONTAL SECTION.

anti-friction metal. The oil wells are large and coated inside with enamel paint, so that the oil can be easily kept clean. They are provided with oil sight gauges and cocks for changing the oil when necessary.

REPORT OF PHYSICAL TESTS BY THE ROBERT W. HUNT COMPANY ON THE WATER WHEEL BUCKETS AND CENTERS FOR RISDON IRON AND LOCOMOTIVE WORKS.

	TESTS OF SEPTEMBER 7, 1900.				TESTS OF OCT. 4, 1901.	
	1	2	3	4	1	2
Specimen number	$\frac{8}{20}$	$\frac{8}{20}$	$\frac{8}{27}$	$\frac{9}{7}$	2404	2392
Marks	cent'r	cent'r	cent'r	buckts	buckts	buckts
Original area 5 square inches	.5217	.5178	.5217	.5255	.4889	.4501
Fractured area square inches	.2688	.2922	.2672	.2827	.....	.....
Elongation in 8-inch	1.84	2.14	2.08	2.08	.....	.....
Elastical limit per square inch	39,870	37,080	39,300	41,860	34,770	39,770
Tensile strength per square inch	65,550	62,200	64,980	66,420	57,680	62,880
Per cent. elongation in 8-inch	23 00	26.75	26.00	26.00	30.00	28.00
Character of fracture	silky $\frac{1}{2}$-inch cup	silky ang.	.....	silky cup	silky $\frac{3}{4}$-inch cup	silky $\frac{3}{4}$-inch cup
Per cent. reduction of area	48.48	43.6	49.38	46.2	.....	.....
Accepted or rejected	Acc.	Acc.	Acc.	Acc.	Acc.	Acc.

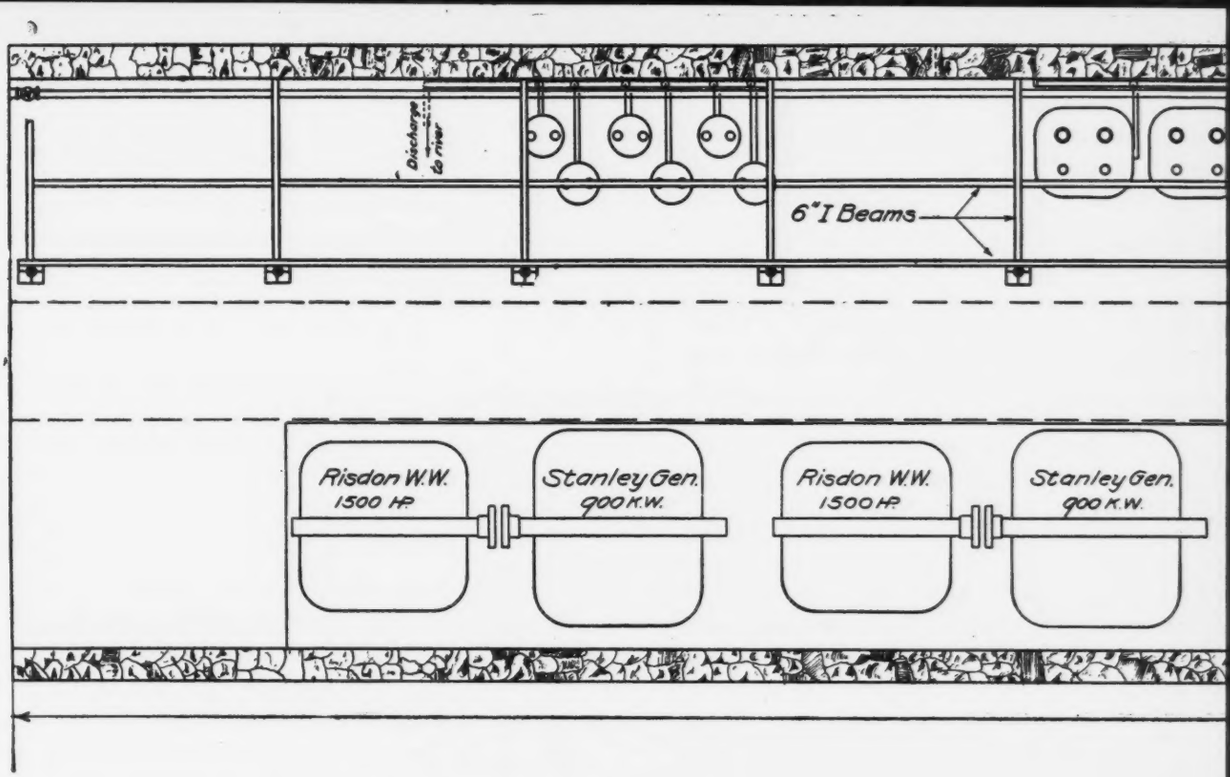
The general arrangement of the gate valves, nozzles and water wheels with reference to themselves and to the coupling flange for driving the generator is shown by the frontispiece, which illustrates a 3000-horsepower set for direct connection to a 2000-kilowatt Stanley inductor type generator. Three of these water wheel and generator sets are now in practically continuous operation in the Colgate power house. They run at 240 revolutions per minute, and the insulating flexible coupling connecting the water wheel and generator shafts consists of eight links of leather attached to pins projecting from two parallel discs, one on the end of the water wheel shaft, as shown in the frontispiece, and the other on an identically similar flange placed on the end of the generator shaft. These units, which are the largest horizontal shaft tangential water wheels in operation in the world, each consist of two wheels mounted on a single shaft, each wheel being driven by a single jet. Each wheel is, furthermore, 8½ feet in diameter, and it is significant of the sturdiness of the wheels to state that at times the blow imparted to the buckets from the impact of the jet of water striking them is upwards of thirty tons. The units are handsomely enclosed in varnished wooden lagging, so deadened that in the power house the wheels run without perceptible noise.

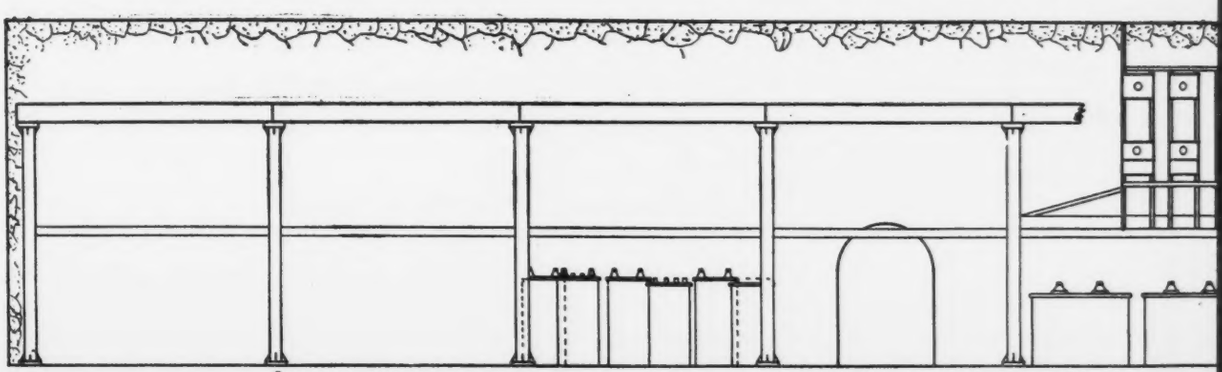
Besides these three 3000-horsepower sets, the Colgate power house contains four other units, each having a capacity of 1500-horsepower and running at 360 revolutions per minute. These units each have water wheels 59 inches in diameter, and are of the same general construction as that of the 3000-horsepower units already described. In addition the station contains two exciter wheels of a capacity of 75-horsepower each, the wheels having a diameter of 24 inches and running at 957 revolutions per minute. The total rated capacity of the water wheel equipment of the power house is therefore 16,500-horsepower.

At the Colgate plant of the Bay Counties Power Company the Lombard Type D governors are used. One governor has already been installed, and has worked so satisfactorily that more governors of the same type are being erected. This governor is one of the several types manufactured by the Lombard Governor Company of Boston, Mass., and is an extremely interesting as well as a very practical machine; in fact, it is almost human in action, and one cannot help but admire the beautiful precision and smoothness with which the various parts of the machine work for a common end—that of giving the proper motion to the water wheel gates or to a deflecting nozzle.

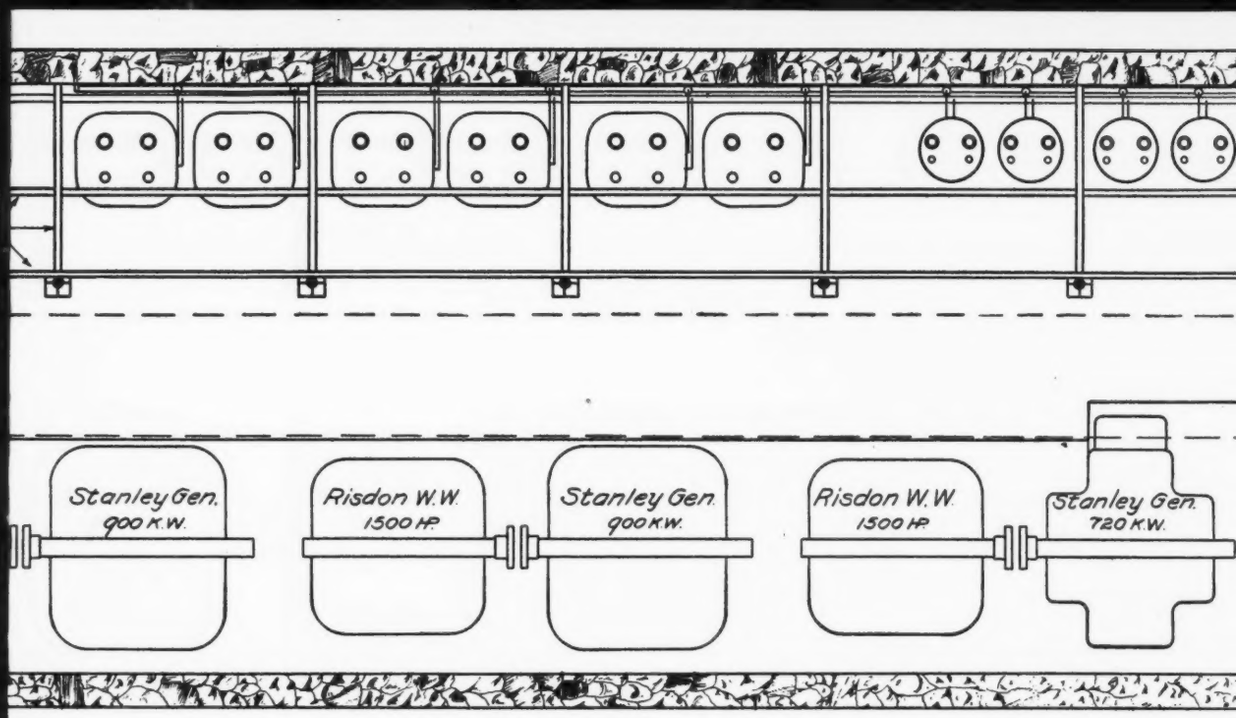
If one has had an opportunity to study the governor in operation, he is surprised at the extreme sensitiveness

A PHOTOGRAPHIC SHOT IN THE WHEEL PIT.

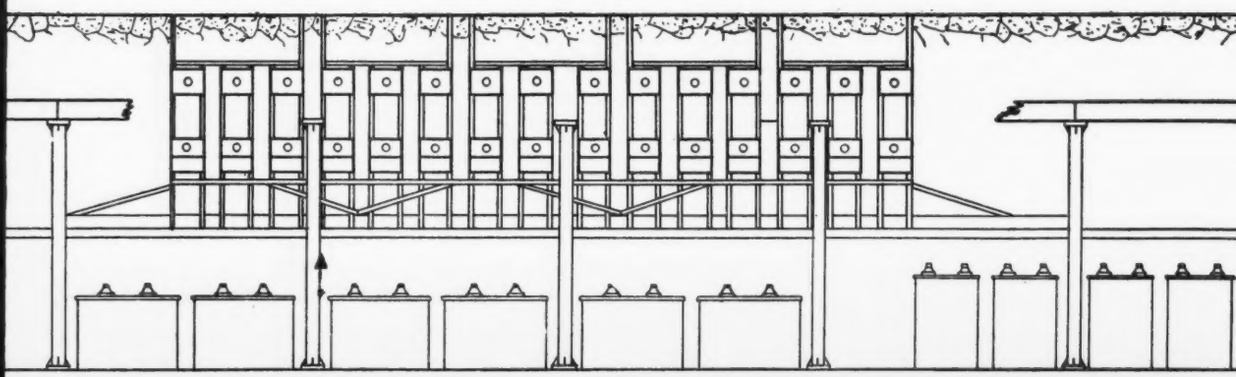

Discharge to river
6" I Beams
Risdon W.W. 1500 H.P.
Stanley Gen. 900 K.W.
Risdon W.W. 1500 H.P.
Stanley Gen. 900 K.W.



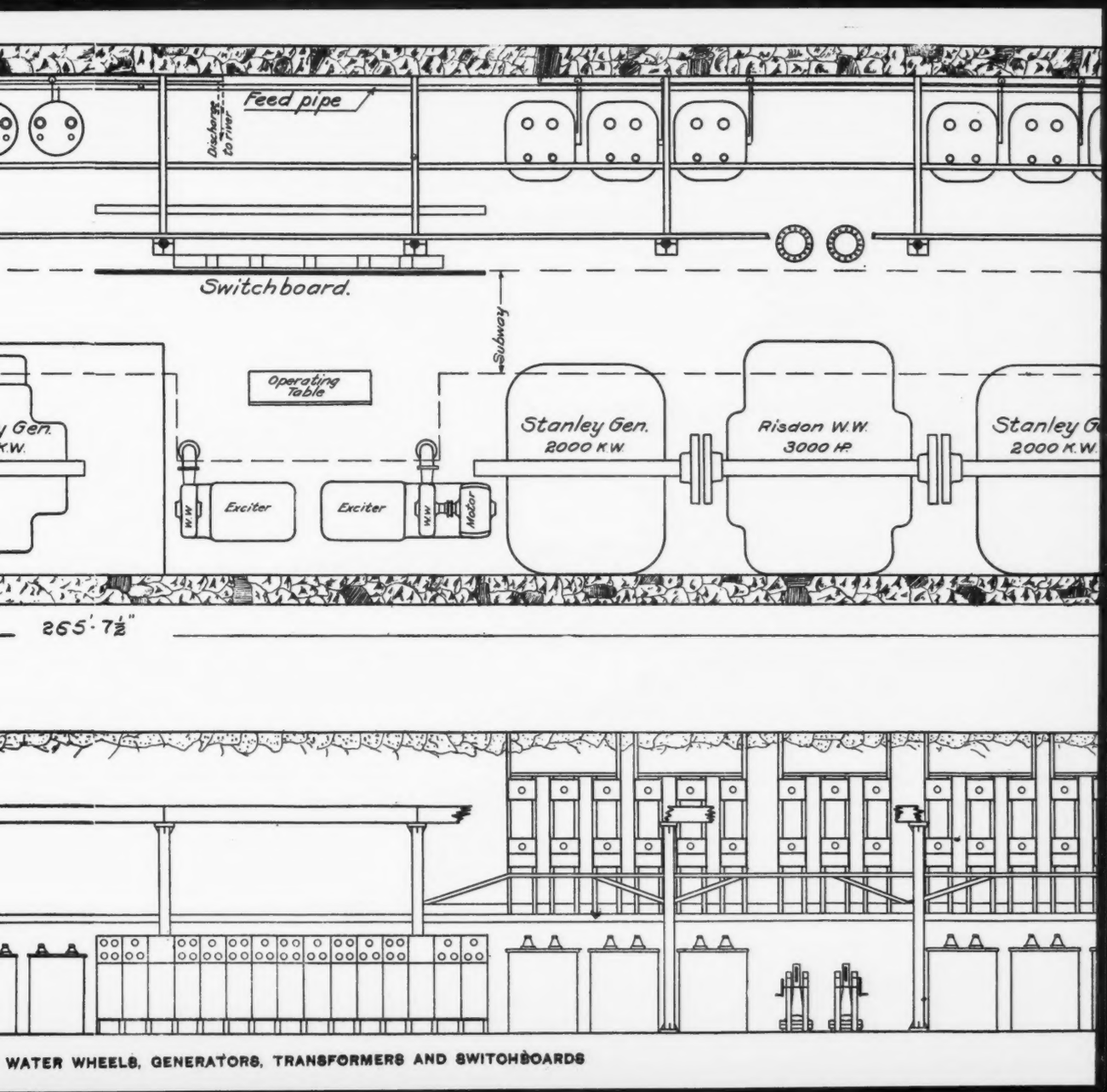
PLAN A



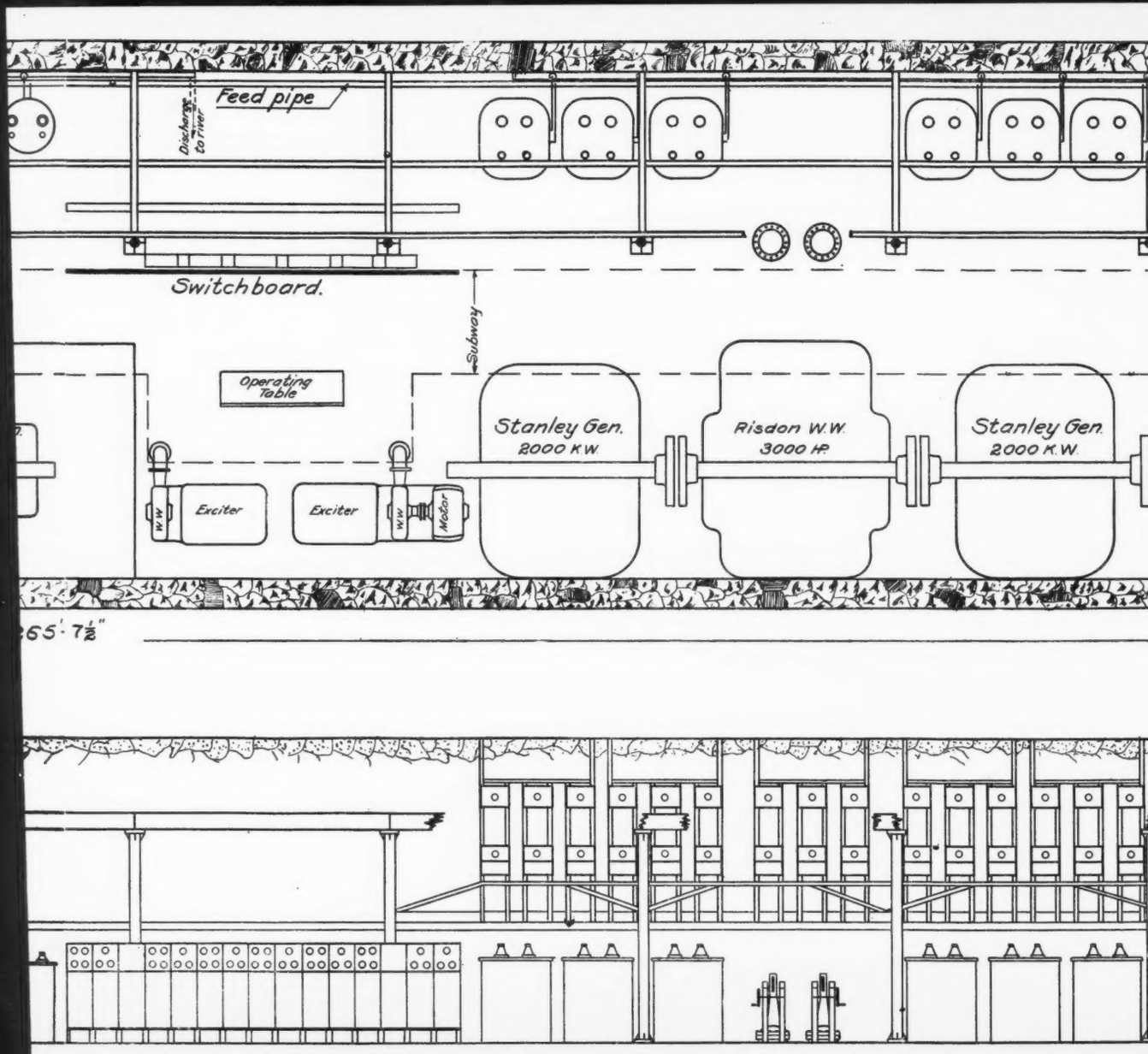
265



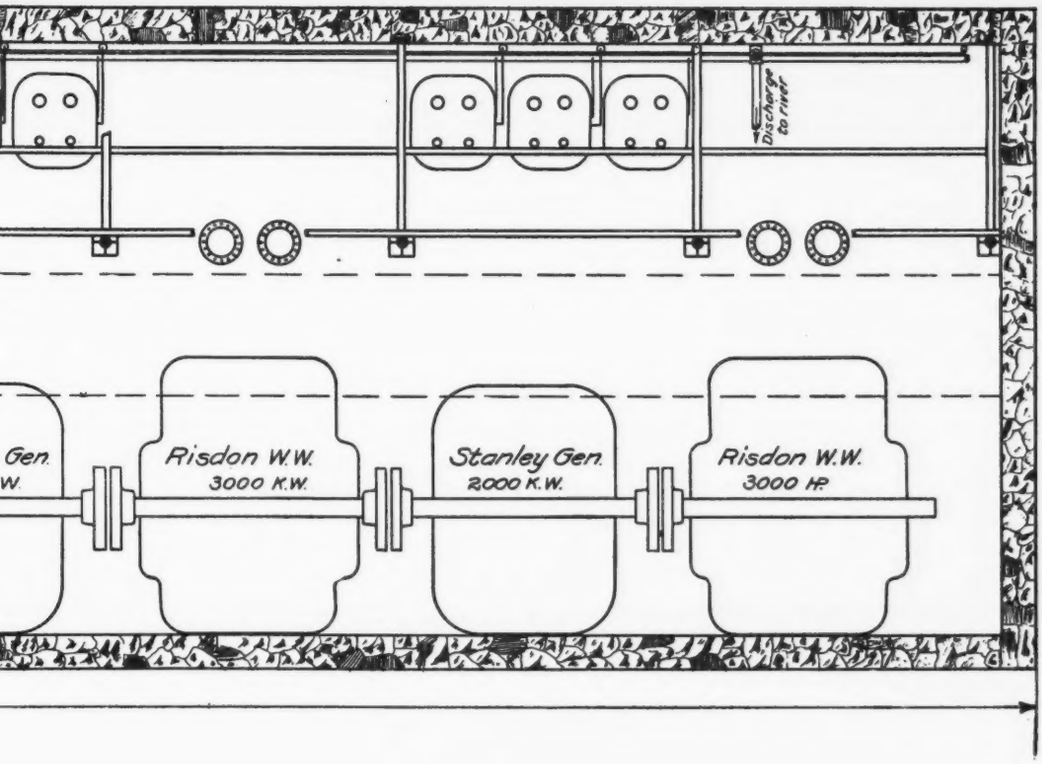
PLAN AND ELEVATION OF THE INTERIOR OF COLGATE POWER HOUSE—SHOWING LOCATION OF WATER WH

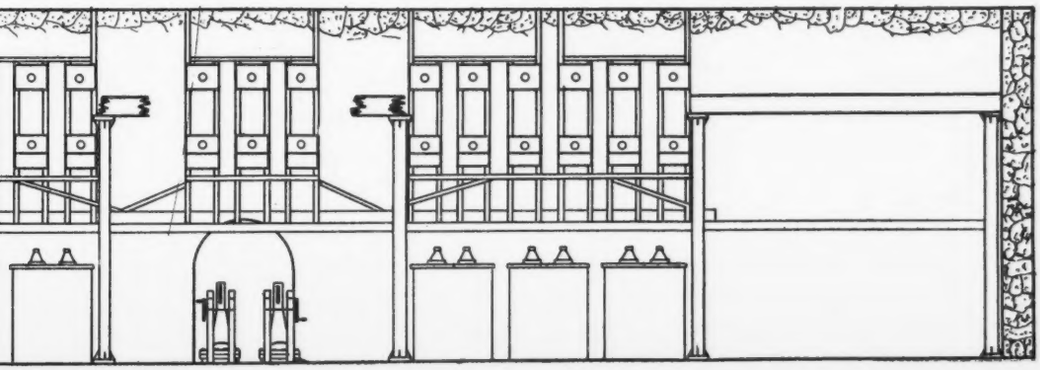


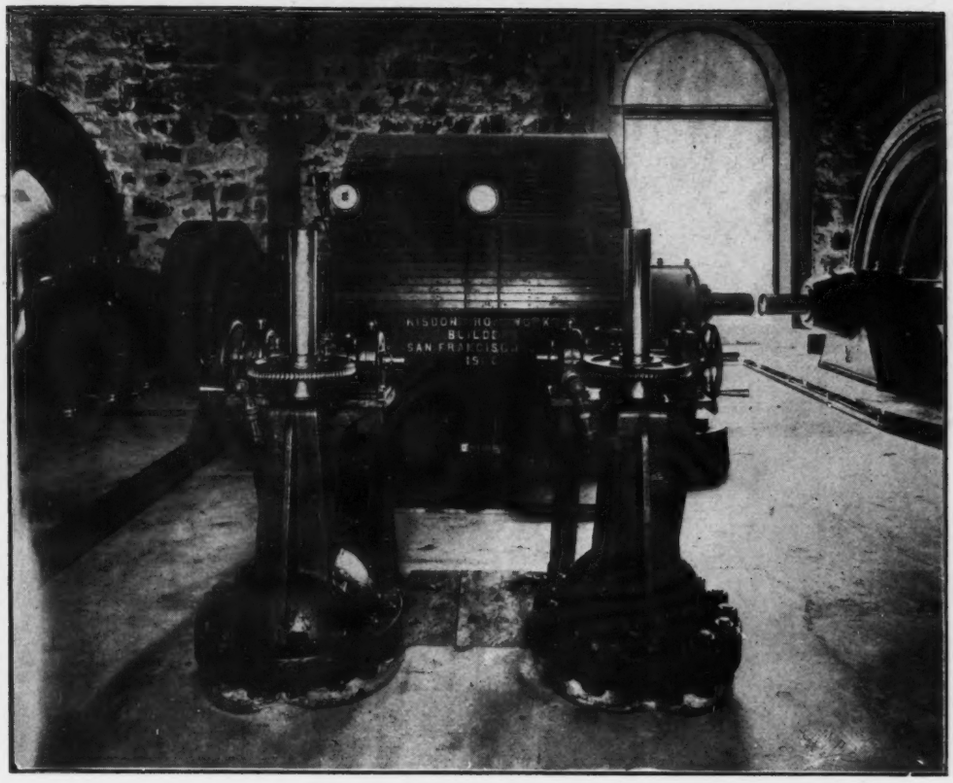
WATER WHEELS, GENERATORS, TRANSFORMERS AND SWITCHBOARDS



WHEELS, GENERATORS, TRANSFORMERS AND SWITCHBOARDS


Discharge to river
Gen.
W.
Risdon W.W.
3000 K.W.
Stanley Gen.
2000 K.W.
Risdon W.W.
3000 HP





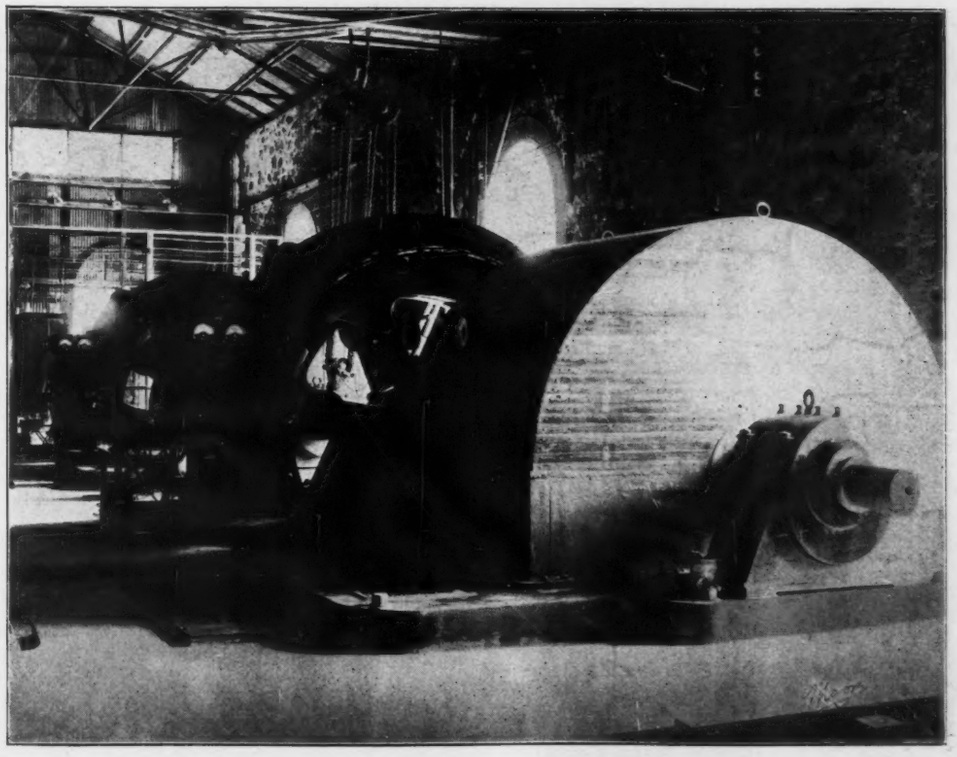
THE APPEARANCE OF THE 3000-HORSEPOWER RISDON WHEEL SETS DOES NOT CONVEY ANY IDEA OF THE GREAT ENERGY THEY CONVERT.

that it has for the slightest variations in speed, while at the same time the ease and positiveness with which many times ponderous water wheel gates are moved to the proper position. On further investigation he notices the simplicity and directness of the various mechanisms. What might seem at first as complex and unnecessary portions of the governor, appear to be of vital importance to its complete action, especially to the anticipatory effect it has for sudden load changes, which is peculiar alone to the Lombard governor.

With this article is shown, on page 15, a side elevation view of the Type D governor, which shows plainly the bed and legs of the governor supporting the hydraulic cylinder from which three stuffing glands project. Mounted on top of the cylinder is the governor top, with its pulleys and governor balls, while in back of the cylinder part of the pump box with the pump pulley can be seen.

Between the legs is a long tank, which is separated in two compartments, the vacuum and pressure parts, as indicated by a row of rivet heads appearing under the bed of the governor. The main governor shaft in front appears very plainly, with the clutch arrangement for disconnecting the governor from the shaft beyond the clutch. The clutch handle shows projecting above the clutch, while the hand wheel by which the gates are operated when the governor is not thrown in is also shown.

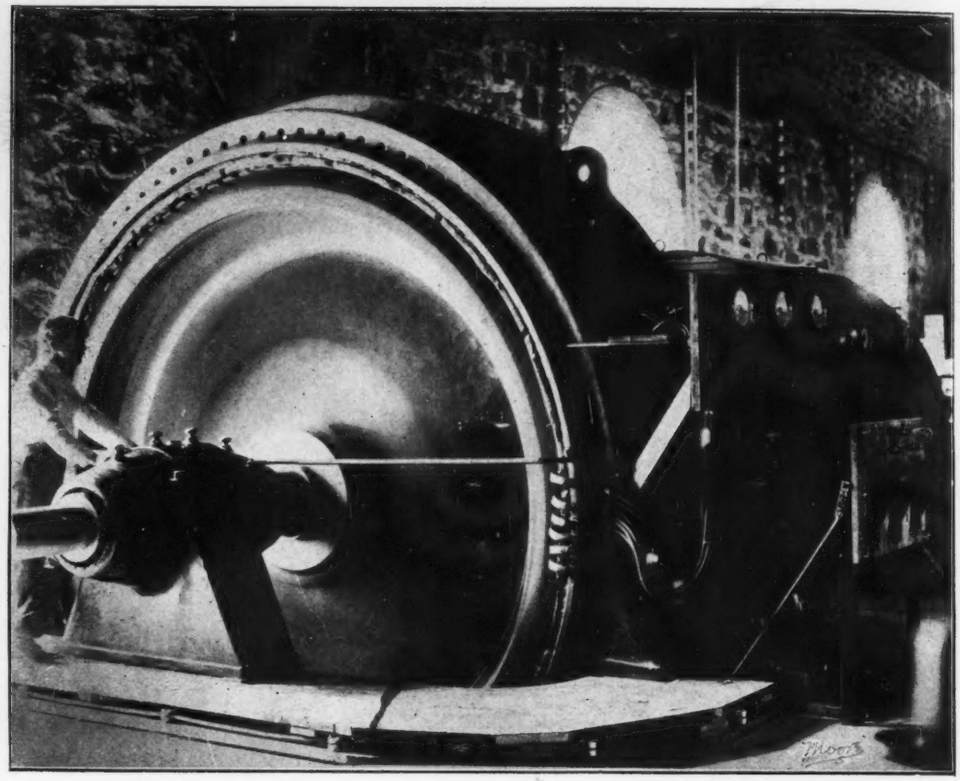
On examination the governor may be divided into four divisions of its parts: First, the pumping system for giving oil under high pressure to the hydraulic cylinder, and then receiving it back again from the vacuum tank to which it was exhausted. Second, the hydraulic cylinder with its various valves and connections for properly distributing the oil, making it do work and then exhausting it. Third, the governor top, which by virtue of the nicely hung governor balls, gives the initiative to the motions of the



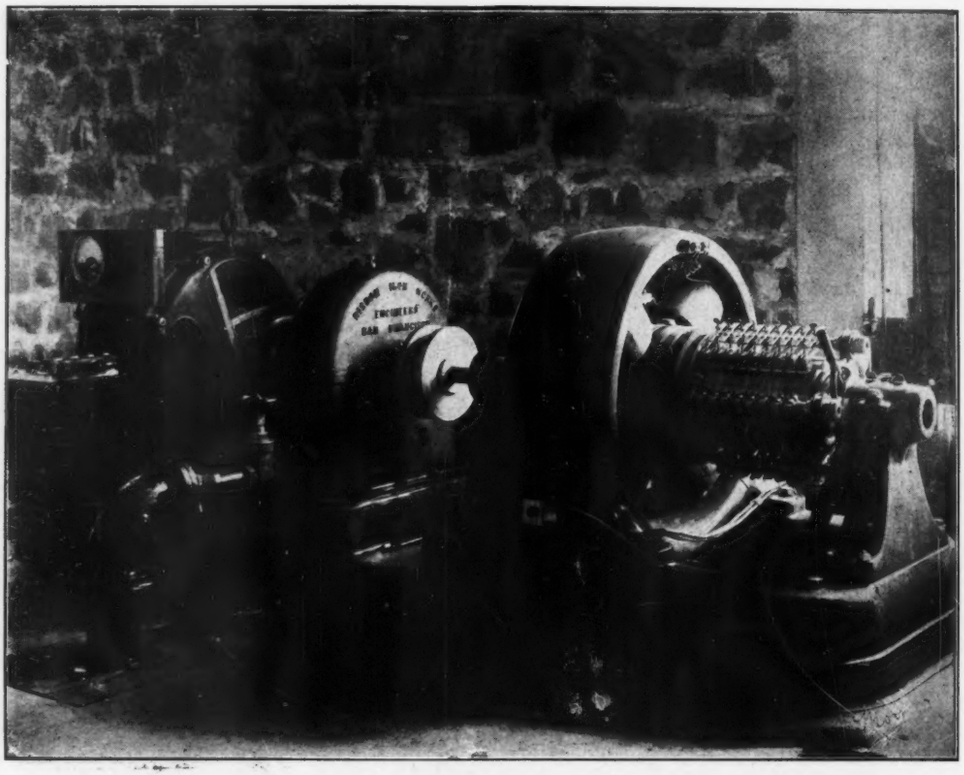
IN THE "BIG UNIT" SECTION AT COLGATE.

hydraulic cylinder; and fourth, the connections between the large piston of the hydraulic cylinder and the water wheel gates or deflecting nozzles.

The action of the governor is as follows: Accurately hung governor balls are made to revolve by driving the governor top pulley from the water wheel shaft in question, and these balls, on account of their centrifugal force, are made to actuate a valve stem attached rigidly to a delicately adjusted triple valve, the case around which is shown on top of the hydraulic cylinder. This valve ports oil so that the upper piston on the cylinder is run in or out according to the position of the governor balls, and the piston has a rod to which is attached a small rack that moves a floating gear shown below the rack. This gear, having no fixed center, moves over the top of a gear below it in turn, and gives motion to the middle valve of the cylinder. By the movement of this valve, oil is ported into the large cylinder below, which moves the piston, and this in turn moves the piston rod, the large rack attached and the gate rigging. All valves are brought back on their center after either slight or large motion of the water wheel gates. One of the conspicuous points of the Lombard governor is its ability to prevent racing.



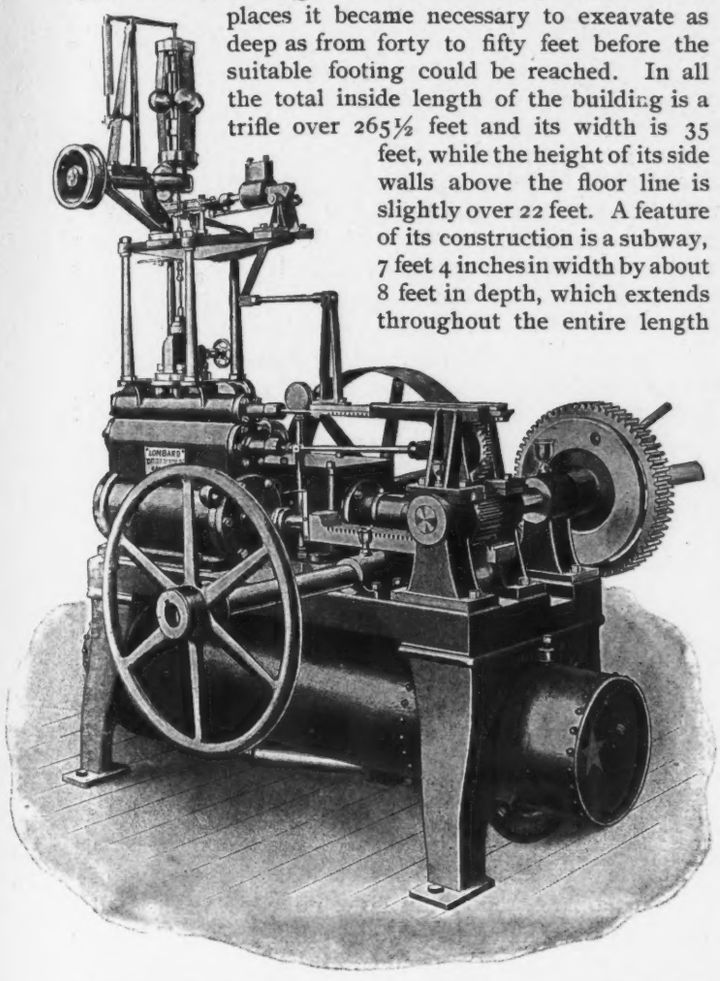
THE 2000-KILOWATT STANLEY INDUCTION TYPE GENERATORS RUN WITH ABSOLUTE PERFECTION



AN INDUCTION MOTOR, A RISDON WATER WHEEL AND A DIRECT CURRENT GENERATOR CONSTITUTES THE EXCITER COMBINATION.

It should be added, that owing to the fluctuations which occur in the main pipe lines from various causes, and to the fact that perfectly uniform pressure is advisable, if not necessary, for the attainment of highest possible efficiency in the operation of the Lombard governor, it is obviously inexpedient to use the main pipe line as a source of water pressure for this service. Fortunately a sizeable and unfailing spring of water rises in the canyon a few hundred feet, by way of the trail, back of the power house. A small rock and cement dam has been thrown across the canyon, and this, serving also as a penstock, supplies an independent source of water under a pressure of 100 pounds per square inch for the operation of the governors.

The building of the Colgate power house is of native rock laid in cement, and its construction is most substantial. Foundations go down to bedrock, and in some places it became necessary to exeavate as deep as from forty to fifty feet before the suitable footing could be reached. In all the total inside length of the building is a trifle over 265½ feet and its width is 35 feet, while the height of its side walls above the floor line is slightly over 22 feet. A feature of its construction is a subway, 7 feet 4 inches in width by about 8 feet in depth, which extends throughout the entire length



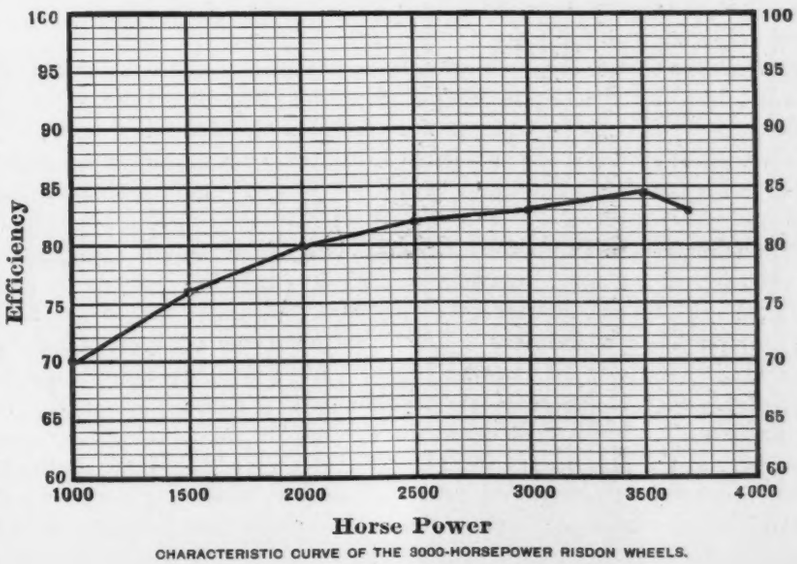
SIDE ELEVATION VIEW OF THE "TYPE D" LOMBARD GOVERNOR USED AT COLGATE.

the building, and in which is run all the busbars and of wiring of the entire station, except those for the high tension lines which are run overhead. The receivers run parallel with and just outside of the north wall of the building, but the pipe lines, which separately supply the water wheels, are laid in concrete, thus forming an integral part of the foundations. All tail races are laid at a grade of three inches per foot, and as the length of the station is parallel with the bank of the river the wheels were set so that their discharge would be thrown direct into the river through independent tail races.

The shafts of the water wheels and generators of the station run lengthwise with it, and those of the 3000-horsepower sets, sets of equal size, that is, those of duplicate water wheel and generator sets, are in line. Take the three 3000-horsepower sets, for instance: At the easterly end of the station is placed, first, a 3000-horsepower Risdon water wheel, then a 2000-kilowatt Stanley generator, then another Risdon wheel and so on until three Risdon wheels and three Stanley generators are in line, alternating with one another. All shafts, whether of water wheel or generator units, carry a flange at each end, and these flanges are fitted for leather link driving, so that any generator may be driven by either of two water wheels, or *vice versa*, excepting, of course, the outer generator and water wheel units. The separation between abutting flanges is $3\frac{15}{16}$ inches, and they are approximately 5 feet in diameter. The shaft lengths of the water wheels and generators are respectively 16 feet 8 inches and 15 feet 10½ inches, while the distance between centers from water wheel to generator to water wheel unit, etc., is 16 feet $7\frac{3}{16}$ inches.

This very flexible arrangement of water wheel and generator units does not exist in the smaller units, for with them each set is independent of the adjoining one. Flexible couplings are provided between each water wheel and its generator, but the sets are separated by a passageway of nearly 3 feet between them. The over all shaft lengths of each of the 1500-horsepower sets is approximately 27 feet, the generator shaft is 13 feet 10⅜ inches in length, the separation between the faces of the coupling flanges varies from 5½ inches to $6\frac{3}{16}$ inches, so the lengths of the water wheel shafts approximates 12 feet 7 inches.

In the center of the station, on the generating or southerly side, are located the two 50-horse-power exciter wheels and generator sets which supply the excitation current for the entire station. These exciters are generally run in parallel, and in order to provide every possible safeguard against shutting down the plant by reason of the choking of the small jet of the exciter wheel, one of the exciter jets has been equipped with a 50-horsepower three-phase induction motor operated direct from the generator busbar. The exciter wheels are always operated with nozzles wide open, and although their nozzles may be deflected manually by a hand lever, this is never done, for the reason that any excess of power delivered by the water wheel beyond the actual requirements for excitation purposes will be delivered to the shaft of the induction motor, which, in turn, will cause the induction motor to act as a dynamo, and thus deliver three-phase current to the generator busbars. On the other hand, should the water wheel fail, the induction motor will instantly pick up the exciter load and carry it without even attracting the attendant's attention to the fact that a change has occurred.



CHARACTERISTIC CURVE OF THE 3000-HORSEPOWER RISDON WHEELS.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS
Devoted to the Conversion, Transmission, and Distribution of Energy.

CONDUCTED BY GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Published monthly. Yearly subscription: Domestic, $1.00: Foreign, $1.50.
Subscriptions can not be begun with back numbers.
The price of single copies is variable.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

PUBLICATION OFFICE:
No. 536 Clay Street, ('Phone Bush 519), San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME XII JANUARY, 1902 NUMBER 1

EDITORIAL.

SOUTHERN CALIFORNIA TRANSMISSIONS.

In the sunny southland of California is a world of electrical engineering development which would, but for its modesty, stand alone as representative of much which is best in American transmission practice. And why should it not be so? Southern California pioneered high voltage lighting transmission in the Pomona plant now passed into history; it pioneered polyphase transmission of power in the Redlands plant, which is still in full load service day in and day out the year round; and it pioneered extreme long distance and extreme high tension transmission in the Santa Ana-Los Angeles transmission of the Edison Electric Company, which has in all probability the most successful record for continuous service of any transmission in the West. More than this the growth of the industry in the southern section of the state has been fully commensurate with the marvellous advances it has made elsewhere, so that today its engineers as a whole have earned the distinction of possessing a length and a breadth of experience in the development of water power at high head and the electrical transmission of its energy which is of incomparable thoroughness.

If one reviews this situation as it stands today from the standpoint of intimate acquaintance with it, he is impressed with the fact that several causes have contributed to the upbuilding of southern California as the scenes of the earliest activity in the development of this new industry. First is the economic condition, wherein the utilization of the energy of mountain streams became a necessity as the only means for surmounting the industrial handicap of high priced fuel. The climate, almost ever dry and possessing absolute immunity from snow, sleet and protracted rain, seemed to invite the use of high and yet higher potentials, and then southern California was very remote from the populous centers of the country, so that it presented an inviting field for the great manufacturing companies to experiment. This they did, generally under coercion, for the fact remains that the most serious difficulty encountered in the promotion and installation of these early transmission enterprises rested in the unwillingness of the great manufacturing companies to build apparatus along lines divergent from their standard practices, as well as in their doubt and incredulity of the technical feasibility of the schemes proposed. In the Pomona plant, while 10,000 volts had been used in Europe, it was but "a laboratory experiment utterly without commercial feasibility"; in the Redlands plant, an electrical engineer who has since achieved national renown, staked his reputation as an engineer that the Redlands generators would not synchronize and run in parallel; and when the eighty-three mile 33,000-volt transmission into Los Angeles was proposed it was characterized as both chimerical and preposterous. The electrical transmission world can never fully realize the difficulties which beset these early enterprises, nor can they ever properly appreciate the service which they gave in hastening the industry into existence. And if the transmission world ever becomes appreciative of any of these instances, it will be of the services of the late Mr. A. W. Decker, whose engineering ability inspired confidence on the part of the promotors and investors, and compelled co-operation on the parts of the manufacturing concerns in the successful accomplishment of these earliest of transmission enterprises. It need not be cited that the engineering of the Pomona plant, the Mount Lowe railway and the Mill Creek No. 1 system of the since absorbed Redlands Electric Light and Power Company are the fruits of his brain, to convince of his standing in the chronicles of engineering development in southern California. Looking beyond this, as is meet, one will find that the chronicles of southern California engineering development are to a very great measure the chronicles of transmission engineering development from its very earliest stages, and in them Mr. Decker's name must ever be uppermost.

It is a recreation of no mean order to make a tour of the various electrical enterprises of the southern portion of the State, especially if it be done during the winter months—the winter months of paradise, when tens of thousands from all parts of the world are making this sunny southland their Mecca. The business interests of Los Angeles, for instance, as with all other sections, do not seem to be at all commensurate with the size and importance of the place, but then the majority of people go to Los Angeles to live, not to make money. The city must stand high in per capita wealth, and, indeed, the same is true regarding the entire region. As a result the electricity supply of southern California has a distinct caste, so to speak, from that of almost any other large community. The greater portion of the consumption of electric power is for electric railway purposes, which,

together with the lighting service, constitute the bulk of the electrical business in and about Los Angeles in particular. Elsewhere, however, the bulk of the load is due to pumping for irrigation purposes as well as to lighting. Practically nowhere is the load due to ordinary commercial electric power service of any great significance, for southern California is a land almost without factories or heavy manufacturing interests. Aside from the retailing which goes with every populous community, its generally magnificent hotels and its fruit and viticultural interests are the exponents of its two leading lines of industry. The tourist travel during the winter months is enormous, and its countless miles of matchless orchards possess all that is necessary to make a semi-rural life of absolute idealism.

The electrical situation resulting from these conditions is a very interesting one: The system of the Edison Electric Company, of Los Angeles, which embraces almost the whole of the San Bernardino and San Gabriel valleys, as well as extending southerly as far as Santa Ana, carries its peak loads in the summer months, its winter loads being of minor concern. This is due to its heavy pumping loads, which run continuously for six or eight or ten months during the year, according to the amount of rainfall. Here an anomalous situation is presented: The greatest demand upon the transmission system comes at the time of the minimum flow of water in its streams. Were the rivers running full there would be plenty of water in the valleys below and irrigation by pumping would be unnecessary. The demand for power is imperative and must be met, and so it is that the conservation, conduction and application of water has, perforce, become a far more exact science in southern California than elsewhere. A single inch of water has a value of many hundreds if not thousands of dollars, if it be perennial, for irrigating use alone, and when to this value is added that due to the development of power from it, as is possible in the high mountain ranges, there becomes ample incentive for the exercise of extraordinary effort toward its development and application. Strenuous efforts have been put forth, therefore, to develop water from every possible source, but these efforts are not less zealous than are those directed toward securing absolute immunity from interruption from accident occurring to the waterways.

The labors of the hydraulic engineer as evinced in the work on the watercourses of the transmission plants of the Santa Ana and San Gabriel river canyons are of the highest possible standards of excellence. They are built as if for all eternity, and an incidental to their stability, yet vital to the transmission service they render, is the fact that they have never failed in the performance of their duty. Shutdowns of these power plants from flume or ditch breakings are not within their experience, nor is it likely they will ever know trouble from these causes. Absolute continuity of service so far as the power plant is concerned is the reward for this class of construction, and it is a reward well worth the effort. Indeed, let the log books of the water power stations of California tell their own story, which will be that tunnels give a reliability in service that is not possible of attainment with flumes or ordinary ditches. More than this it must be said that the watercourses of the great transmissions of the future, whenever they are operated at high heads and with comparatively small volumes of water, will be of the substantial type of construction wherein natural rock or concrete is used to the absolute exclusion of timber or earthwork of any sort.

Of this, then, we may be sure. The great electrical transmissions of southern California are far in the lead of those of other sections in the substantiality of their watercourses, yes—as far ahead as they were in the lead of all others in the pioneering work which has made them famous throughout the engineering world.

THE INVENTION OF "EAVE-TROUGH" INSULATORS.

One of those situations which sometimes confront editors to their great discomfiture has been brought about through the publication in these columns* of the claim of Mr. Fred. M. Locke that the "'eave-trough' insulator, as used by the Bay Counties Power Company and the Standard Electric Company of California, are wholly of his (Locke's) designs and patents." That this statement is a palpable error is indisputable, for on December 18, 1900, United States letters patent No. 664,301 was issued to Richard H. Sterling upon a form of so-called "eave-trough" insulator for use on high tension lines, which, from the illustrations and description appearing in the specifications of the patent, appears to be identical with the insulator which the Standard and Bay Counties companies are using to-day. This patent is now owned by the Stanley Electric Manufacturing Company, of Pitisfield, Mass., and publication of the evident inadvertance in which credit is claimed for the "designs and patents" upon which the eave-trough insulator is established, works a regretted injustice to Mr. Sterling as well as, furthermore, a serious injury to the Stanley Company.

It would seem to the disinterested observer that, unless it be checked at the outset, a controversy is likely to develop over the inventorship of this very efficient type of insulator, but it cannot be pointed out wherein such a controversy would be other than unnecessary and unfortunate. The patent stands in Mr. Sterling's name as inventor and in the Stanley Electric Manufacturing Company's name as assignee. Moreover, Mr. Locke is the exclusive manufacturer of the insulator, which is known to the trade as Locke's "No. 304 'Victor' Combination Insulator for 60,00 Volts," and it is a reasonable presumption that he is manufacturing it under license from the Stanley Company. All is well, then, and so let it remain in peace and harmony.

*THE JOURNAL, Volume XI, page 264, November, 1901.

INDUCTION MOTORS AND ROTARY CONVERTERS.*

BY CHAS. F. SCOTT.

TWO important functions of an alternating current transmission system are the production of mechanical power and the furnishing of direct current. The induction motor and the rotary converter have become the usual means of transforming energy into these forms. The wide extent to which they are now used is a notable feature of recent electrical progress. An examination of their behavior in service, especially in connection with other apparatus which might be used for the same purposes, will indicate the particular characteristics which have made them so successful. Occasion will be taken, also, to note some of the important inter-relations between the various kinds of receiving apparatus and the transmission circuit and the generators by which they are supplied with current.

Power may be produced by the synchronous motor or by the induction motor. A comparison between the two motors may be made by placing in parallel columns their respective characteristics in services, *i. e.*, those which concern the operation rather than the design. An induction motor with a secondary of the "squirrel cage" type, started by applying a low electromotive force to the primary, is taken for comparison—the description will require modification is some particulars if the secondary circuit is provided with adjustable resistance. These are of minor importance and do not affect the general comparison.

THE INDUCTION MOTOR.

Synchronous Motor.	Induction Motor.
AUXILIARY APPARATUS.	
1. A starting motor; or, if self-starting, some form of resistance or transformer for reducing the voltage.	1. A two-way main switch with auto transformers giving a low electromotive force for starting. This may be located at any distance from the motor.
2. An exciter, driven by the motor or otherwise, with circuits to switchboard and motor.	2. No exciter is required.
3. Rheostats for exciter and motor.	3. No field rheostats are required.
4. Instruments for indicating when field current is properly adjusted.	4. No instruments are required.
5. Main switch and exciter switches.	5. No exciter switches are required.
6. A friction clutch is required in many cases.	6. No friction clutch is required, as the motor starts its load.
CONSTRUCTION.	
1. Armature winding.	1. Primary winding.
2. Field winding with many turns. Liable to accident from "field discharge" if exciting current is suddenly broken; or from high electromotive force by induction from the armature if the field circuit is open.	2. Secondary, short-circuited.
3. Collector rings and brushes.	3. No moving contacts on "squirrel cage" secondary.
STARTING—NORMAL.	
1. Motor is brought up to speed without load; if starting motor is used, the main motor must be brought to proper speed and "synchronized"; if self-starting, the starting devices must be cut out of circuit at proper time.	1. Throw switch to starting and then to running position.
2. Exciter is made ready for delivering proper current and the motor field must be excited, adjustments being made by rheostats until instruments give proper indication.	2. There is no exciter. (The motor is magnetized by lagging current from the generator.)
3. Load is thrown on by friction clutch or other means.	3. The motor starts its own load.
STARTING—ABNORMAL.	
1. If the several operations in starting be performed improperly or in wrong order injury may result. If a starting motor is used the synchronizing may be attempted at an improper speed or phase; if the motor is self-starting and it is connected to the circuit without the starting devices a large current will flow which may induce a high electromotive force in the field circuit; if the field circuit be open a high electromotive force may be induced in it at other times also.	1. The only possible error is in starting with the switch in the running or full voltage position, which simply causes the motor to exert a greater torque and consume a greater current than is necessary.
2. If a load having inertia be applied by closing the friction clutch too quickly the motor may be overloaded and stopped.	2. The motor starts its own load and requires no friction clutch.
3. If motor stops owing to failure of current supply, it is not self-starting when the current returns. An attendant is always required for starting.	3. The motor will stop if the current is cut off at the power house and then start again when the current is supplied to the circuit.
STARTING AND MAXIMUM RUNNING TORQUE.	
1. The starting torque of the self-starting motor is very small and an excessive current is required for developing it. The motor starts as an induction motor, but inefficiently, as the designs which is best for synchronous running is not good for starting.	1. The starting torque is adjustable and may be several times full load torque.
2. The maximum torque is several times the full load torque, and occurs at synchronous speed; below this speed the torque is very small; any condition which momentarily lowers the speed causes the motor to stop.	2. The maximum torque is usually greater than that of the synchronous motor, but it occurs at a reduced speed and there is a large torque at lower speeds.
SPEED.	
1. The motor has a single definite speed; at other speeds its torque is very small and the current is very large.	1. The motor may be designed for a practically constant speed, with large torque at lower speeds; or for several definite speeds by changing the number of poles; or for variable speed work, such as is required for cranes, elevators, hoists and the like.

*A paper read at the eighteenth annual convention of the American Institute of Electrical Engineers, Buffalo, August 22, 1901.

SYNCHRONOUS MOTOR.	INDUCTION MOTOR.
CURRENT.	
1. If there is useful starting torque the current required for producing it is very great.	1. The starting current may be made proportional to the torque, and is one and one-half to two and one-half times that required for the same torque at high speed.
2. The running current depends upon the wave form. If the wave form of the motor and of the circuit differs, a corrective current will follow which cannot be eliminated by adjustment of field excitation.	2. The running current is practically independent of the difference in wave form, as it has no wave form of its own.
3. The running current depends upon uniformity of alternations of the current, *i.e.*, upon the uniformity of the speed of the generator and other synchronous motors. The motors attempt to follow the generator speed exactly. If the latter pulsates, the motors pulsate also; they vibrate about a mean position, "hunting" or "pumping." One motor pumping incites others. The current is increased even though the conditions may still be operative.	3. The current is practically independent of fluctuations in generator speed, as there is a slip between the synchronous and the actual speed of the motor.
4. The running current depends upon the relation between the field current (which is adjusted by the attendant) and the electromotive force of the circuit. The main current may be made leading or lagging or theoretically it may be neither. The electromotive force of the circuit is an element which is under the partial control of the attendants at every motor as well as at the generator station.	4. The current is not subject to any adjustments which the motor attendant can make, nor is the electromotive force of the circuit in any way under his control.
POWER FACTOR.	
1. As the power factor is the relation between actual current and energy current, it is dependent upon wave form, hunting and field current. Under favorable conditions the motor may have a high power factor; under many actual conditions it may not; under some conditions the highest attainable power factor is less than that of the induction motar.	1. The power factor varies with load, but is definite and is practically independent of wave form and hunting.
2. The current may be lagging or leading, depending upon the motor field strength.	2. The current to the motor is always a lagging current.
REACTION UPON GENERATOR AND CIRCUIT.	
1. The motor impressess its own wave form on the circuit.	1. The motor has no wave form to impress upon the circuit; its tendency is to smooth out irregularities in a wave which is not a sine wave.
2. A motor may augment the fluctuations in generator speed by the oscillation of its own armature. One motor may increase the disturbance in the circuit so as to interfere with other motors which would not have been seriously affected.	2. The motor has a damping action upon fluctuations in frequency; in some cases a synchronous motor which hunts may run smoothly when an induction motor is connected to the same circuit.
3. As the current may be either lagging or leading, the drop in electromative force in the generator and between generator and motor may be either more or less than that which could be caused by a non-inductive load or by an induction motor.	3. The drop in the electromotive force is always greater than would be caused by non-inductive load.
4. If a short circuit occurs in the transmission system the motor acts as a generator, which thereby greatly increases the current and the intensity of the short circuit.	4. The motor does not generate current when there is a short circuit.
5. If the circuit is opened, either by a switch, a circuit breaker, a fuse or the breaking of the line, the motor speed falls, its electromotive force is no longer in phase with that of the circuit; the two are thereby added, thus doubling the normal electromotive force and bringing increased strains on the insulation and the opening devices.	5. The motor does not generate electromotive force when it is disconnected from the circuit.
CAUSES WHICH MAY ACCIDENTALLY STOP A MOTOR.	
1. Momentary lowering of electromotive force caused by short circuit on the line, or by accident at another motor, or by error in synchronizing a generator, or by the "switching over" of the motor from one circuit to another, is apt to cause the motor, particularly if carrying load, to fall from synchronism and come to rest.	1. Momentary lowering of electromotive force causes momentary decrease in speed.
2. A heavy load, even momentary, may exceed the limiting torque and cause the motor to drop from synchronism, even though the load be removed immediately. The connection between generator and motor is rigid.	2. An excessive load receives the stored energy of the motor and of the load itself as the motor falls; when the excess load is removed the motor speed increases again. The connection between generator and motor is elastic.
3. If the generator speed suddenly increases, a motor carrying a load having inertia may be unable to increase its speed quickly without exceeding the limiting torque, which will cause the motor to stop.	3. The motor readily follows changes in generator speed.
SUMMARY.	
1. The motor is an active element in the system; it acts as a generator in impressing its own wave form, its electromotive force and its fluctuation upon the circuit. These fluctuations may be caused by an intermittent load.	1. The motor is a passive element in the system. Each motor attends to its own work and does not try to run the system.

SUMMARY.—CONTINUED.

SYNCHRONOUS MOTOR.	INDUCTION MOTOR.
2. The motor is a sensitive element in the system. Its successful operation is dependent upon a proper relation between the design of the motor itself and of other machines connected with the system. Its successful operation also depends upon the proper adjustment and freedom from speed fluctuation in generators and other motors. It is liable to momentary variations from normal conditions, such as a sudden overload and sudden increase of generator speed or a momentary fall in electromotive force.	2. The motor is not sensitive to differences in the design of other apparatus operating on the same system.
3. The motor requires skill and care on the part of the attendant for starting, for readjusting and for keeping the various brushes and auxiliary apparatus in proper condition.	3. No experience and electrical skill are required of the attendant and there is little or nothing to get out of order either through carelessness or design.
4. The power factor is under the control of the operator and the current may be made leading or lagging. Instruments are necessary in order that proper adjustments may be made by the attendant.	4. The motor has a definite power factor, depending upon the load; the out of phase current does not vary greatly at different loads. The changing load, therefore, has comparatively little effect upon the drop in voltage, and in regular service there is little liability that the motor will disturb the electromotive force of the circuit.
5. The motor and its operation are complex and involve many possibilities of accident.	5. The motor and its operation are simple and reliable.

The synchronous motor is obviously not suitable for general distribution of power, owing particularly to its lack of starting torque, the skill required in attendance and the liability of the motor to stop if the conditions become abnormal. These objectionable features, however, are of much less importance when motors are installed in substations or are of sufficiently large size to justify an attendant.

The characteristic of the synchronous motor which may be particularly advantageous is the fact that the power factor of the current can be varied and that the current may be made leading. In this way the current required and the drop in the generator and transmission circuit may be reduced. If the motor is used on a circuit supplying induction motors the synchronous motor may be given a leading current, thus neutralizing the lagging current to other motors. The extra current taken by the synchronous motor for this compensation necessitates a larger size than would otherwise be required.

The characteristic of the induction motor which is usually regarded as most unfavorable in comparison with the synchronous motor, is the fact that its current is always a lagging current. In a comparison with synchronous motors only large sizes should be included, as synchronous motors of small size are not to be seriously considered in practical work. The induction motors of large size have relatively high power factors, *i. e.*, the out of phase current is small. Moreover, this current is definite in kind and nearly constant for different loads, so that it is a definite and constant element which may be provided for. It may therefore create less disturbance on the system than the out of phase current of the synchronous motor, which is either lagging or leading, large or small, depending upon the intelligence and care of the attendant and upon other conditions. In one case the voltage of the system is under the control of the attendant in the power house and the lagging current to induction motors which are running with either constant or varying load is practically constant. On the other hand, when synchronous motors are used, the voltage of the system is dependent upon all the motors, and uncertain or disastrous results are liable to be caused by adjustments by the various motor attendants. In many cases it is far better to provide the generators and circuits suitable for supplying the lagging current required by induction motors' rather than to attempt to gain the theoretical advantages attending the use of synchronous motors, as the securing of these advantages requires that so many conditions be favorable. At best the synchronous motor is less satisfactory to operate and is far more sensitive to abnormal or emergency conditions than the induction motor.

The foregoing considerations will indicate why it is that the induction motor has taken such a leading place, while the synchronous motor has been less favored and is now rarely considered seriously as a competitor of the induction motor except in large sizes.

THE ROTARY CONVERTER.

The rotary converter is in its relation to the transmission system essentially a synchronous motor. The foregoing characteristics of the synchronous motor, except those which involve a load upon the motor, apply also to the rotary converter. The starting, however, is somewhat simpler, as there is no load to accelerate except the armature. No separate exciter is necessary, as the converter can furnish its own direct current for exciting. A converter may be compound wound so that as it is loaded the increased excitation changes the out of phase current in such a way as to compound the voltage, thus overcoming the drop which would otherwise occur in generator and transmission circuits; whereas, the synchronous motor would cause a falling off in voltage. The rotary converter is generally used in units of considerable size placed in substations having skilled attendants. For these reasons the operation of rotary converters does not involve so many difficulties as that of synchronous motors.

Direct current is obtained from alternating circuits, either by the rotary converter or a motor-generator, in which either a synchronous or an induction motor is employed.

The rotary converter has the advantage over the motor-generator in point of cost, there being but one machine instead of two; in point of efficiency, there being the loss in one machine instead of two; and in its effect upon the voltage of the transmission system, as it may be compounded to overcome the drop which would otherwise occur in generator and transmission circuit. On the other hand, the electromotive force of the direct current delivered by the coverter depends upon the electromotive force received; whereas, the electromotive force of a motor driven generator is independent of the electromotive force of the supply circuit, and may be adjusted or compounded as may be desired. It is found in practice, however, that the voltage delivered by a rotary converter can be satisfactorily adjusted and controlled by regulating devices or by compounding, so that usually the close relation between the electromotive forces at the two ends of the converter is not disadvantageous, provided the electromotive force of the supply circuit is reasonably constant.

This statement applies to those cases in which a practically constant voltage is desired. There are, of course, special cases in which the voltage is to be adjusted over a very wide range or where for other reasons the motor-generator is to be preferred. In many cases the motor may be used either with or without transformers, whereas they would be required with a rotary converter.

A motor-generator employing a synchronous motor does not seem to possess any essential advantage over the converter except that sometimes the motor may receive the line voltage without transformers, and in some cases the independent control of the direct current voltage is desired. The use of the synchronous

Name.	Synonym.	Chemical Expression for Molecule. Composition.	Atomic Weight. Atomic Mass.	Molecular Weights or Mass.	Specific Gravity Compared to Air. Air 1 at 0°C.	Weight of 1 cu. ft. in Lbs. 29.92 in. Mercury 32°F.	Weight of 1 Liter in grams 760 mm. Mercury at 0°C.	Cu. Ft. in 1 Lb. at 29.92 in. of Mercury at 32°F.	Liters in 1 gram at 760 m.m. of Mercury at 0°C.	C Weight of 1 cu. ft. in Lbs. in 1 cu. ft.	C Weight of 1 gram in grams in 1 Liter.	A Weight in 1 cu.
Hydrogen		H_2	1.0075 R	2.015	.0695 K	.00561 K	.08987 K	178.23 K	11.12700			.00
Oxygen		O_2	16. R	32.	1.1051 K	.08921 K	1.4290 K	11.209 K	.69974			
Nitrogen		N_2	14.045 R	28.09	.9714 K	.07842 K	1.2561 K	12.752 K	.79608			
Air		By Wgt {O=23 N=77} K By Vol {O=20.9 N=79.1}			1. K	.080728 K	1.2931 K R	12.387 K	.77330			
Water Vapor		H_2O		18.015								
Carbon Vapor		C_2	12.001 R	24.002		.06733	1.07852	14.853	.92710	.06733	1.07852	
Carbon Monoxide	Carbonic Oxide	CO		28.001	.9674 K	.07810 K	1.251 K	12.804 K	.79931	.033473	.53618	
Carbon Dioxide	Carbonic Acid Gas — Carbonic Anhydride	CO_2		44.001	1.5290 K	.12343 K	1.977 K	8.102 K	.50581	.033665	.53922	
Methane	Marsh Gas Fire Damp After Damp	CH_4		16.031	.5560 K	.04488 K	.719 K	22.301 K	1.39700	.033598 K	.53812	.01
Ethane	Methane.	C_2H_6		30.047		.08428	1.2413 K	11.866	8.05500	.067333	.99153	.01
Propane		C_3H_8		44.063		.12359	1.97997	8.091	.50508	.100984	1.61780	.02
Butane		C_4H_{10}		58.079		.16291	2.60977	6.1381	.38320	.134647	2.157	.02
Pentane		C_5H_{12}		72.095		.20223	3.23959	4.9491	.30866	.168317	2.69633	.03
Hexane		C_6H_{14}		86.111		.24154	3.86942	4.1400	.25844	.201973	3.23575	.03
Acetylene		C_2H_2		26.017	.92 B	.07298	1.16907	13.701	.8554	.06733	1.07853	.00
Ethylene	Olefiant Gas Ethylene Illuminants	C_2H_4		28.032	.9847 K	.07949 K	1.273 K	12.580 K	.7855	.068063	1.090	.01
Propylene		C_3H_6		42.048		.11794	1.88943	8.4782	.5293	.100984	1.6178	.01
Butylene		C_4H_8		56.064		.15726	2.51924	6.3587	.39693	.134624	2.15707	.02
Benzene	Benzole Vapor Unfixed Illuminants.	C_6H_6		78.051	.899	.21893	3.50722	4.5675	.2851	.201973	3.23559	.01

R.—Atomic weights according to Richards, from table prepared by F. W.

PROPERTIES OF

of in	C Weight of in grams in 1 Liter.	H Weight of in lbs. in 1 cu. ft	H Weight of in grams in 1 Liter.	O Weight of in lbs. in 1 cu. ft	O Weight of in grams in 1 Liter	Reaction with Oxygen.	Volume Contraction	Volume CO_2 Formed	Volume of Oxygen Required for Combustion	Volume of Air Required for Combustion	Weight for C
		.00561 K	.08987 K			$H_2 + \frac{1}{2}O_2 = H_2O$.	$1\frac{1}{2}H$	No Reaction.	$\frac{1}{2}$	2.39	
				.08921 K	1.4290 K	No Reaction	No Reaction.	No Reaction	No Reaction	No Reaction	N
						No Reaction	No Reaction.	No Reaction	No Reaction	No Reaction	N
						No Reaction	No. Reaction	No Reaction	No Reaction	No Reaction	N
						No Reaction	No Reaction	No Reaction	No Reaction	No Reaction	N
	1.07852					$C_2 + O_2 = 2CO$ $C_2 + 2O_2 = 2CO_2$	No Contraction 1C	No Reaction 2C	1 2	4.78 9.56	
3	.53618			.0446	.71438	$CO + \frac{1}{2}O_2 = CO_2$	$\frac{1}{2}CO$	$1CO$	$\frac{1}{2}$	2.39	
5	.53922			.089766	1.43779	No Reaction	No Reaction.	No Reaction.	No Reaction	No Reaction	N
8 K	.53812	.011282	.18075			$CH_4 + 2O_2 = CO_2 + 2H_2O$	$2CH_4$	$1CH_4$	2	9.56	
3	.99153	.01695	.24973			$C_2H_6 + 3\frac{1}{2}O_2 = 2CO_2 + 3H_2O$.	$2\frac{1}{2}C_2H_6$	$2C_2H_6$	$3\frac{1}{2}$	16.73	
4	1.61780	.02261	.36217			$C_3H_8 + 5O_2 = 3CO_2 + 4H_2O$.	$3C_3H_8$	$3C_3H_8$	5	23.90	
7	2.157	.02826	.45272			$C_4H_{10} + 6\frac{1}{2}O_2 = 4CO_2 + 5H_2O$.	$3\frac{1}{2}C_4H_{10}$	$4C_4H_{10}$	$6\frac{1}{2}$	31.07	
7	2.69633	.033912	.543246			$C_5H_{12} + 8O_2 = 5CO_2 + 6H_2O$.	$4C_5H_{12}$	$5C_5H_{12}$	8	38.24	
3	3.23575	.03956	.633650			$C_6H_{14} + 9\frac{1}{2}O_2 = 6CO_2 + 7H_2O$.	$4\frac{1}{2}C_6H_{14}$	$6C_6H_{14}$	$9\frac{1}{2}$	45.41	
	1.07853	.005652	.090544			$C_2H_2 + 2\frac{1}{2}O_2 = 2CO_2 + H_2O$.	$1\frac{1}{2}C_2H_2$	$2C_2H_2$	$2\frac{1}{2}$	11.95	
3	1.090	.01143	.183020			$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$.	$2C_2H_4$	$2C_2H_4$	3	14.34	
4	1.6178	.016956	.271630			$C_3H_6 + 4\frac{1}{2}O_2 = 3CO_2 + 3H_2O$.	$2\frac{1}{2}C_3H_6$	$3C_3H_6$	$4\frac{1}{2}$	21.51	
4	2.15707	.022608	.362176			$C_4H_8 + 6O_2 = 4CO_2 + 4H_2O$.	$3C_4H_8$	$4C_4H_8$	6	28.68	
3	3.23559	.016956	.271633			$C_6H_6 + 7\frac{1}{2}O_2 = 6CO_2 + 3H_2O$.	$2\frac{1}{2}C_6H_6$	$6C_6H_6$	$7\frac{1}{2}$	35.85	

le prepared by F. W. Clark (1900), Journal of the American Chemical Society, Volume XXI, No. 2, February, 1900. K.—Kent's Eng

ERRATA { Weight of oxygen requ
" " " "
" " air "
" " " "

OF GASES.

	Weight of Oxygen Required for Combustion of		Weight of Air Required for Combustion of		Weights of Products of Combustion							
					CO_2				H_2O			
	1 Lb in Lbs	1 gram in grams	1 Lb in Lbs.	1 gram in grams.	Lbs. from 1 cu. ft	Lbs. from 1 Lb.	Grams from 1 Liter.	Grams from 1 Gram	Lbs from 1 cu. ft	Lbs. from 1 Lb.	Grams from 1 Liter.	Gra...
	7.943		34.535		No Reaction.	No Reaction	No Reaction	No Reaction	.050159	8.941	.8035	8.
	No Reaction		No Reaction		No Reaction.	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No
	No Reaction		No Reaction		No Reaction.	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No
	No Reaction		No Reaction		No Reaction	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No Reaction.	No
	No Reaction		No Reaction		No Reaction	No Reaction	No Reaction	No Reaction	No Reaction.	No Reaction.	No Reaction.	No
	2.6663 1.333		11.592 5.7964		.24683	3.6668	3.9515	3.6668	No Reaction.	No Reaction.	No Reaction.	No
	.57145		2.4843		.12272	.15713	1.9659	1.5713	No Reaction	No Reaction	No Reaction.	No
	No Reaction		No. Reaction		No Reaction	No Reaction	No Reaction	No Reaction.	No Reaction	No Reaction	No Reaction.	No
	3.992		17.354		.12315	2.7443	1.973	2.7443	.10087	2.2474	1.6158	2.
	3.728		16.21		.24675	2.9285	3.6355	2.9285	.15153	1.7985	2.2325	1.
	3.6318		15.786		.37029	2.9959	5.932	2.9959	.20212	1.6353	3.2380	1.
	3.5817		15.571		.49368	3.0304	7.908	3.0304	.24429	1.5507	4.0475	1.
	3.5508		15.437		.61718	3.0517	9.8865	3.0517	.30323	1.4993	4.8579	1.
	3.5308		15.352		.74058	3.066	11.862	3.066	.3542	1.4645	5.66609	1.
	3.0745		13.367		.24672	3.3822	3.954	3.3822	.050519	.6924	.80932	.
	3.4246		14.889		.24951	3.139	3.9962	3.139	.10217	1.2852	1.6360	1.
	3.4246		14.889		.37029	3.1393	5.9315	3.1393	.15171	1.2862	2.4302	1.
	3.4246		14.889		.4937	3.1392	7.9084	3.1392	.20212	1.2852	3.2380	1.
	3.0750		13.369		.7405	3.3826	11.862	3.3826	.15157	.6924	2.4285	.

Kent's Engineering Handbook. B.—Barker. P.—H. L. Payne, Journal of Analytical and Applied Chemistry. E.—E. H. Earnshaw. F. &

ygen required for combustion of C to CO — 1.333
" " " " " C to CO_2 — 2.6663
r " " " " C to CO — 5.7964
" " " " C to CO_2 — 11.592

OF GASES.

Volume of Air Required for Combustion	Weight of Oxygen Required for Combustion of		Weight of Air Required for Combustion of		Weights of Products of Combustion.					
					CO_2				H_2	
	1 Lb. in Lbs.	1 gram in grams	1 Lb. in Lbs.	1 gram in grams.	Lbs. from 1 cu. ft.	Lbs. from 1 Lb.	Grams from 1 Liter.	Grams from 1 Gram.	Lbs from 1 cu. ft.	Lbs. from 1 Lb.
2.39	7.943		34.535		No Reaction.	No Reaction	No Reaction	No Reaction	.050159	8.941
No Reaction	No Reaction		No Reaction		No Reaction.	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.
No Reaction	No Reaction		No Reaction		No Reaction.	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.
No Reaction	No Reaction		No Reaction		No Reaction	No Reaction	No Reaction.	No Reaction.	No Reaction.	No Reaction.
No Reaction	No Reaction		No Reaction		No Reaction.	No Reaction	No Reaction	No Reaction	No Reaction.	No Reaction.
4.78 2.56	2.6663 1.333		11.592 5.7964		.24683	3.6668	3.9515	3.6668	No Reaction.	No Reaction.
2.39	.57145		2.4843		.12272	1.5713	1.9659	1.5713	No Reaction	No Reaction
No Reaction	No Reaction		No Reaction		No Reaction	No Reaction	No Reaction	No Reaction.	No Reaction	No Reaction
2.56	3.992		17.354		.12315	2.7443	1.973	2.7443	.10087	2.2474
16.73	3.728		16.21		.24675	2.9285	3.6355	2.9285	.15153	1.7985
23.90	3.6313		15.786		.37029	2.9959	5.932	2.9959	.20212	1.6353
31.07	3.5817		15.571		.49368	3.0304	7.908	3.0304	.24429	1.5507
38.24	3.5508		15.437		.61718	3.0517	9.8865	3.0517	.30323	1.4993
45.41	3.5305		15.352		.74058	3.066	11.862	3.066	.3542	1.4645
11.95	3.0745		13.367		.24672	3.3822	3.954	3.3822	.050519	.6924
14.34	3.4246		14.889		.24951	3.139	3.9962	3.139	.10217	1.2852
21.51	3.4246		14.889		.37029	3.1393	5.9315	3.1393	.15171	1.2862
28.68	3.4246		14.889		.4937	3.1392	7.9084	3.1392	.20212	1.2852
35.85	3.0750		13.369		.7405	3.3826	11.862	3.3826	.15157	.6924

. K.—Kent's Engineering Handbook. B.—Barker. P.—H. L. Payne, Journal of Analytical and Applied Chemistry. E.—E. H. E

ht of oxygen required for combustion of C to CO — 1.333
" " " " " " C to CO_2 — 2.6663
" air " " " " C to CO — 5.7964
" " " " " " C to CO_2 — 11.592

stion. H_2O.			Specific Heat at Constant Volume.	Specific Heat at Constant Pressure.	Volumetric Specific Heat per 1 cu. ft.	Volumetric Specific Heat per 1 Liter	Calorific Values.			
Lbs. from 1 Lb.	Grams from 1 Liter.	Grams from 1 Gram.			Constant	Pressure.	B.T.U. per Cu. Ft.	B.T.U. per Pound.	Calories per Liter.	Calories per Kilo.
8.941	.8035	8.941	2.41226 K	3.40900 K	0.019 P	.000675 CAL. K	345.4 R	62032. R&S.	3.07406 R.	34462. R&S.
No Reaction.	No Reaction.	No Reaction.	0.15507 K	0.21751 K	0.019 P	.000685 CAL. K.				
No Reaction.	No Reaction.	No Reaction.	0.17273 K	0.24380 K	0.019 P	.000675 CAL. K				
No Reaction.	No Reaction.	No Reaction.	0.16847 K	.023751 K	0.019 P	.000677 CAL. K				
No Reaction.	No Reaction.	No Reaction.								
No Reaction.	No Reaction.	No Reaction.					973.6 CAL. R&S.	14544. R&S.	8.66378 CAL. R&S.	8080. R&S.
No Reaction.	No Reaction.	No Reaction.	0.1758 K	0.2479 K	0.019 P	.000684 CAL. K	341.2 R.	4326. R&S.	3.03668 CAL. R.	2403. R&S.
No Reaction.	No Reaction.	No Reaction.	0.1535 K	0.217 K	0.027 P	.000946 CAL. K				
2.2474	1.6158	2.2474	0.4683 K	0.5929 K	0.027 P	.000940 CAL. K.	1065. R	23513. R&S.	94785 CAL. R	13063. R&S.
1.7985	2.2325	1.7985					1861. R	22232. CAL. R	16.5629 CAL. R	12351.2 CAL. R
1.6353	3.2380.	1.6353					2657. R	21642. CAL. R	23.6473 CAL. R	120239 CAL. R
1.5507	4.0475	1.5507					3441. R	21263. CAL. R	30.6249 CAL. R	118133 CAL. R
1.4993	4.8579	1.4993					4285. R	21180.7 CAL. R	37.8695 CAL. R	11767.6 CAL. R.
1.4645	5.66609	1.4645					5017. R	20908.5 CAL. R	44.6513 CAL. R	1616.4 CAL. R
.6924	.80932	.6924					1493.4 R.	20590. CAL. R.	13.29126 CAL. R.	114329 CAL. R.
1.2852	1.6360	1.2852	0.173 K	0.404 K	0.032 CAL. K.	.0011339 CAL. K.	1674.0 R	21344. R&S.	14.8986 CAL. R	11858. R&S.
1.2862	2.4302	1.2862					2509.0 R	21411.5 CAL. R	22.3301 CAL. R.	118896 CAL. R
1.2852	3.2380	1.2852								
.6924	2.4285	.6924					4012. R.	17847. R&S.	35.7068 CAL. R.	9915. R&S.

.—E. H. Earnshaw. F. & S.—Fauvre & Silbermann.

motor does not remove the objections to the rotary converter, which are based on the fact that it is a synchronous machine.

A motor-generator employing an induction motor has the advantage of employing induction instead of synchronous apparatus, thereby securing many of the advantages set forth in the comparison between synchronous and induction motors. Circuits which are supplied by generators in which the speed has a rapid and periodic fluctuation, or in which for any other reason the use of a synchronous machine is impracticable or undesirable, may nevertheless operate an induction motor driving a generator with full satisfaction. The various characteristics of the induction motor under emergency conditions, such as sudden overload, momentary interruption or lowering of the voltage of the supply circuit, may cause little or no inconvenience if the induction motor is used, whereas, it might cause serious interruption to a rotary converter or a synchronously driven generator. The induction motor driving a generator is also to be preferred where units are quite small and the attendance is unskilled. The rotary converter, like the synchronous motor, is unsuited for general distribution in small units.

The foregoing statements and comparisons involving the rotary converter doubtless comprise the principal reasons why this apparatus is being so widely adapted and is in such general use. To indicate the wide use of this apparatus it may be stated that the Westinghouse Electric and Manufacturing Company, with which the writer is connected, has sold over 400 rotary converters. Of this number 30 per cent. are for a frequency of sixty cycles or more. The aggregate output is over 165,000 kilowatts.

Most of this apparatus is now installed and is in successful operation. In fact, the difficulties in connection with the installation and operation of rotary converters on circuits which are suited for them are trivial and do not materially differ in amount from those which may be expected to occur in connection with other kinds of apparatus.

The very wide use of the induction motor and the rotary converter is an established fact, and it is believed that many of the reasons for their selection in preference to other kinds of apparatus have been set forth in the foregoing notes.

Many of the specific relations between the induction motor and the rotary converter and the supply system have been indicated. There is obviously a close relation between the alternator and the apparatus which it supplies. The conditions are radically different from those involved in incandescent lighting. An alternator which may be quite satisfactory for lighting purposes may be highly inadequate for successfully supplying current for either induction motors or rotary converters. For supplying current to induction motors an alternator should have good inherent regulation. The lagging current taken by induction motors requires a greater increase in field current for maintaining a given voltage than is required when the load is non-inductive. In order that the field current may not be excessive, the generator should be properly proportioned to have close regulation. The adjustment of the field current by external devices is not a wholly satisfactory substitute for close inherent regulation. Suddenly changing loads or the throwing on or off of motors causes fluctuations in voltage, as the external devices cannot act quickly enough to prevent the disturbance. The necessity of good inherent regulation is all the more necessary where the motors are large in proportion to the size of the generator and where loads are fluctuating.

THE ALTERNATING GENERATOR.

For the operation of rotary converters the generator speed should be uniform. Engines which are sufficiently uniform in angular velocity to enable generators to run successfully in multiple may nevertheless be unsuited for operating rotary converters or synchronous motors. It is preferable also that generators for operating rotary converters should have good inherent regulation, not only in order that the electromotive force may be maintained at heavy loads, but also for the purpose of holding the converter rigidly in synchronism. If the alternating field is comparatively weak, as is usual in machines of poor regulation, there may be a shifting of the magnetic field back and forth with different armature currents, quite similar to the shifting of load in direct current machines. It is obvious that if the effective position of the field poles may shift back and forth, this shifting is comparable with fluctuations in generator speed, and becomes a source of unsteadiness in the system which may contribute to the "hunting" of rotary converters. This shifting may occur also in a machine having a strong field if a large proportion of the magnetizing force is absorbed in the iron of the field magnet, *i. e.*, a machine with a saturated field. Such a machine may have good electromotive force regulation and still be of an inferior type for the driving of synchronous machinery.

It follows, therefore, that a generator which is to supply induction motors or rotary converters should be selected with reference to the service which it is to supply. In some cases unsatisfactory results have been obtained in the use of motors or converters, duplicates of those which have given full satisfaction elsewhere. The trouble has been located in fluctuating speed or in the characteristics of the alternator supplying the current.

A transmission system must be considered as a unit and the inter-relation between the alternator and the apparatus to which it supplies power must be fully considered.

The theoretical arguments which are occasionally urged against the alternating system, the induction motor and the rotary converter, find their most effective answer in the plants which are now in operation and in their record of service.

The induction motor and the rotary converter to-day represent the survival of the fittest, and confirm the judgment of those engineers who have consistently and persistently advocated their use.

INDUSTRIAL GAS.—XXII.

BY FRANK H. BATES.

PROPERTIES OF GASES.

THE table, "Properties of Gases," will be found serviceable in the calculation of general problems involving the combustion of fuel.

ABBREVIATIONS.

R—Atomic weights according to Richards, from table prepared by F. W. Clarke, Journal of the American Chemical Society, Volume XXI, No. 2, February, 1900.

K—Kent's Engineering Hand-book.

B—Barker.

P—H. L. Payne, Journal of analytical and Applied Chemistry.

E—E. H. Earnshaw.

F. & S.—Fauvre & Silbermann. When the term *CAL* is used, the value has been derived from another value of the table, and the abbreviation with *CAL* refers to same; thus *CAL* F. & S. indicates that the value given has been derived from the value of Fauvre & Silbermann.

The volumetric composition of air as given, N=79.3 per cent, O=20.2 per cent. is not serviceable for computation from gas analyses, since at the temperature at which analyses are made the gas would be dry, or would not give indication of its condensible products. In work of this nature, for example, the derivation of furnace conditions from flue gas analysis, use the following percentages:

Composition of air by volume,

N= 79.04 per cent.
O= 20.96 per cent.

100.00 per cent.

"Accept our thanks and congratulations on the article in the November JOURNAL describing our gas and electric system. It is well written, finely displayed and, needless to say, has our hearty endorsement," writes H. J. Edwards, secretary and manager of the Electric Improvement Company of San Jose, Cal.

"THE JOURNAL is of more than ordinary value, especially in the elucidation of the practical difficulties encountered in transmission."—J. R. Bibbins, Detroit, Mich.

SAN FRANCISCO GAS AND ELECTRIC COMPANY.

AT the annual meeting of the San Francisco Gas and Electric Company the following named directors were elected to serve during the fiscal year beginning on January 22d: William B. Bourn, George H. Collins, William T. Dutton, J. Downey Harvey, C. Osgood Hooker, Frank B. King, E. J. McCutcheon, Louis E. Monteagle, Daniel T. Murphy, A. H. Payson and Rudolph Spreckels. Of this number those who served on the former board are Messrs. Spreckles, Payson, Murphy, Hooker and Harvey.

The new board immediately proceeded to organize. W. B. Bourn was chosen president and Captain A. H. Payson vice-president.

The financial statement presented by the secretary was as follows:

ASSETS.

Real estate, construction and plant	$ 9,708,573 33
Pipes, conduits, lamps and meters	4,365,381 29
Patents and licenses	150,000 00
Oil, coal, etc	119,137 65
Cash on hand	16,741 71
Sundry assets	58,882 13
Supplies, tools, etc	122,195 41
Amount due from consumers	119,196 06
Amounts due from sales of residue, etc	28,967 54
Total	$14,689,075 12

LIABILITIES.

Bonds	$ 623,000 00
Interest on bonds	7,415 00
Unpaid dividends	7,605 12
Pay rolls due	33,149 80
Sundry credits	252,854 88
Bills payable	315,000 00
Deposits on gas and current	43.512 21
Depreciation and reserve fund	412,253 75
Capital stock	12,994,284 36
Total	$14,689,075 12

POWER PLANTS OF THE PACIFIC COAST.

THE combination of science and audacity which characterizes much of the long distance transmission work done during the last few years in California was strikingly brought out at the 220th meeting of the New York Electrical Society, held January 15th, by F. A. C. Perrine, D. S., who lectured on "The Power Plants of the Pacific Coast." Dr. Perrine said that one of the objects of his lecture was to show the men in the East that the far Westerners were no mere rough and tumble engineers, and it was generally admitted that this point was abundantly proved. A more wonderful series of pictures of brilliant engineering triumphs than that thrown on the screen by Dr. Perrine has seldom been presented to a scientific audience.

Dr. Perrine's work has been such as to make him a recognized authority on the subject of long distance electrical transmission. As consulting engineer he had much to do with the pioneer work of the Standard Electric Company, and is now president of the Stanley Electric Manufacturing Company, of Pittsfield, Mass., the designing engineers and manufacturers of electrical apparatus which has made extreme potentials possible.

During the discussion Mr. T. C. Martin mentioned the fact that the present week was one which would be notable in the history of the American Institute of Electrical Engineers and the New York Electrical Society, inasmuch as on one of its evenings the institute learned the details of the most marvelous achievement known in the transmission of intelligence, the sending of a wireless message across the Atlantic, from the lips of the man who had done it, and on another evening the society listened to a description of the longest power transmission in the world, that from Colgate to San Francisco, 215 miles long, by one who had taken a most active part in the work.

Dr. Perrine's paper, which was most entertaining as well as being of great technical value, is to be published by the society.

A "NO CURE, NO PAY," BOILER COMPOUND.

IN a folder recently issued by Poett & Center it is stated that Crosscup's XXX Boiler Compound has been on the market for two years, as a result of which it is confidently asserted that it is not an experiment but a scientific mixture prepared to suit individual cases. It is a further fact that it is being used by many of the largest consumers of boiler compound on the Pacific Coast, to whom it has always given uniformly excellent satisfaction.

Crosscup's XXX Boiler Compound is guaranteed to stop all corrosion and pitting, to remove all scale, prevent priming and to keep the boilers in first-class condition at less cost per horse-power than any other boiler compound on the market. It is highly recommended for use in all classes of steam plants, as it contains no acid or other substance that could possibly injure the boilers.

Messrs. Poett & Center, who hold the general agency for the sale of the compound and are located at 123 California street, San Francisco, announce to any one who is desirous of trying the compound, that they will ship sufficient quantity to supply any plant, whether large or small, for sixty days under the condition that if the compound proves satisfactory at the expiration of that time, payment for the compound shall be expected; if the compound does not prove satisfactory no charge shall be made for it.

A BUSY YEAR FOR CROCKER-WHEELER INTERESTS.

THE year which has just come to a close has been a prosperous one for the Crocker-Wheeler Company of Ampere, N. J., which reports a record-breaking midwinter business and finds it difficult to keep the production up to the demand. The following are some of the recent shipments: Two 400-kilowatt generators to the Vandergrift Construction Company; one 300-kilowatt generator to Stetson & Co. of Philadelphia; one 150-kilowatt generator to the D'Olier Engineering Company of West Camp, N. Y., and one 40-kilowatt generator and twenty-eight motors to the Smith-Brooks Publishing Company plant in Denver, Colorado. The United States Tube Company of Buffalo, N. Y., has been supplied with a motor equipment, and the electrical equipment of the Con. P. Curran printing establishment in St. Louis, Mo., which takes the place of line shafting, has been completed. Orders for a large number of motors have been received from Armour & Co., The American Bridge Company and The Marion Steam Shovel Company. An order for a 30-kilowatt special generator has been received from His Highness The Sultan of Linga. The machine is to be installed in the royal palace, which is on an island near Singapore.

ELECTRICITY IN WATER GAS MANUFACTURE.

SCHMIDT, in comparing the economic value of coal and electricity as sources of heat energy* arrives at the conclusion that, on the average, only 30 per cent. of the energy is utilized in the former case; whereas in the latter case this percentage is 90. For this reason he recommends that electrical heating be used in the manufacture of water gas, instead of the usual process of supplying the necessary heat by direct combustion under air blast. He bases his calculations on the economical conditions existing in Switzerland, and expresses the opinion that it would be easy to adapt carbide furnaces to the manufacture of water gas.

"THE JOURNAL is not so well known in this city as it should be, for to my mind it treats practical problems in engineering in a way that no other journal touches them," writes Frank C. Smallpeice, of the School of Practical Science, of Toronto, Canada, in entering his subscription order.

The Western Electrical Instrument Company has moved its factory from 114 William street, Newark, N. J., to Waverly Park, Essex County, N. J.

*Science Abstracts, No. 2249 (1901).

Lombard Water Wheel Governors

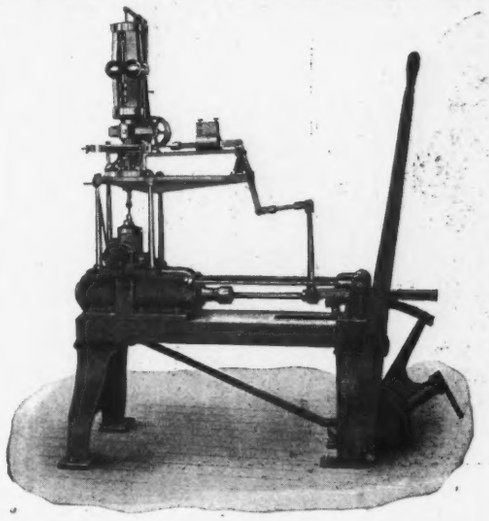
ARE GUARANTEED TO GIVE THE MOST ACCURATE SPEED REGULATION ATTAINABLE

300,000

horsepower in use

Adapted to all makes of water wheels under all operating conditions

Write for catalogue



Type F,

shown in cut, is specially adapted to Pelton and all other forms of Tangential water wheels

Estimates and drawings promptly furnished

THE LOMBARD GOVERNOR CO. 36 WHITTIER STREET (Roxbury District)

Boston, Mass.

Pacific Electrical Works

MANUFACTURERS INSULATED WIRE

Factory and Offices: Central Avenue and Thirty-Second Street, Los Angeles, Cal.

Weatherproof

Underwriters'

Slow Burning

Feeder Cables

Re-covering a Specialty

Office

Magnet

Annunciator

Prices on Application

PACIFIC ELECTRICAL WORKS LOS ANGELES CAL.

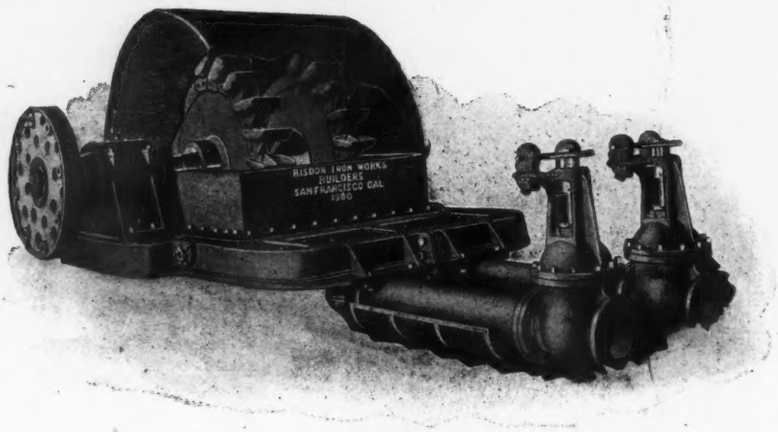
Sales Agent THE CHAS. F. SLOANE CO.

Stimson Building, Los Angeles

Mills Building, San Francisco

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

Tangential Water Wheels



3000-HORSEPOWER UNIT AT COLGATE STATION TRANSMITTING POWER 225 MILES

We build Water Wheels for any head and for any power. Complete electrical power generator wheels a specialty. Large wheels up to 50 feet diameter for driving compressors.

SEND FOR CATALOGUE NO. 4

RISDON IRON WORKS

Office and Branch Works, Folsom and Steuart Sts.
Main Works and Yards, Potrero.

San Francisco, California

All our Wires—New Code Standard

NEW YORK INSULATED WIRE COMPANY

Write for our new catalogue

Main Office, 13-17 Cortlandt Street, New York

JOHN R. COLE, Sales Agent,
33 Second Street, - - - - - - SAN FRANCISCO

GRAPHITE PRODUCTIONS

Graphite Resistance, Graphite Brushes, Graphite Paint
Graphite Crucibles . . Graphite for all Purposes

JOSEPH DIXON CRUCIBLE COMPANY

Factory and Home Office: Jersey City
304 Market Street, SAN FRANCISCO

GILLESPIE'S INSULATOR PINS

This pin is made of seasoned eucalyptus, a wood particularly adapted for electrical insulating. Experts declare it the best pin made. In use in most of the electrical transmission plants on the Pacific Coast. We are making pins for the Standard Electric Company, the Bay Counties Power Company, Jno. Martin & Co., and many others. Address,

Hardwood Planing Mill Co. SAN JOSE, CAL.

Have you seen a copy of the new edition of

The American Telephone Journal

The greatest telephone paper ever published. Articles of practical interest to the whole industry. Instructive to all, from the president to the operator.

$200.00 IN CASH OFFERED IN PRIZES

Send for Sample Copy — The American Telephone Journal — 116 Nassau Street City of New York

ANNOUNCEMENT!

THE CALIFORNIA INCANDESCENT LAMP COMPANY begs to announce that it has purchased the factory of the now-defunct PACIFIC INCANDESCENT LAMP COMPANY, of San Francisco, and has engaged in the manufacture of strictly first-class ***Incandescent Electric Lamps*** upon a scale never before attempted west of the Mississippi.

In addition to "refilled" or "renewed" lamps, which bear the label ***"Pacific"*** as heretofore, the California Incandescent Lamp Company manufactures entirely new lamps known as the ***"California"*** brand, and which are marketed under the guarantee that they are equal in every respect to the best lamps of any other manufacture.

These lamps are now on the market and are sold at attractive prices, based upon the advantages of local manufacture.

ALL VOLTAGES **ALL CANDLEPOWERS**
ALL WATTAGES **ALL FORMS OF FILAMENTS**

California Incandescent Lamp Company
509-511 Howard Street, : : : : SAN FRANCISCO

CHAS. F. SLOANE,
General Sales Agent,
MILLS BLDG., *SAN FRANCISCO*

Branch Offices:
Seattle Los Angeles
Honolulu City of Mexico

EFFICIENCY OF PELTON WHEELS

The following recent letter, emanating from one of the foremost engineering laboratories of the world, may be of some interest as establishing beyond question the high efficiency of the Pelton Water Wheel:

SIBLEY COLLEGE,
CORNELL UNIVERSITY.

DEPARTMENT EXPERIMENTAL ENGINEERING.
R. C. CARPENTER.

Ithaca, N Y., Oct. 15, 1901.

The Pelton Water Wheel Co.,

San Francisco, Cal.

Gentlemen:---

In accordance with your request for a statement in regard to results obtained in tests made by us on your wheel, beg to say that we have obtained as high an efficiency as 88 per cent in some of our experiments on Pelton wheels.

We recently conducted a series of experiments in which we used various forms of buckets on the rim of the same wheel. The results of these tests seemed to indicate the superiority of the general form of bucket adopted in the Pelton wheel.

Very truly yours,

R C Carpenter

SEND FOR ILLUSTRATED CATALOG

THE PELTON WATER WHEEL CO.

HYDRAULIC ENGINEERS

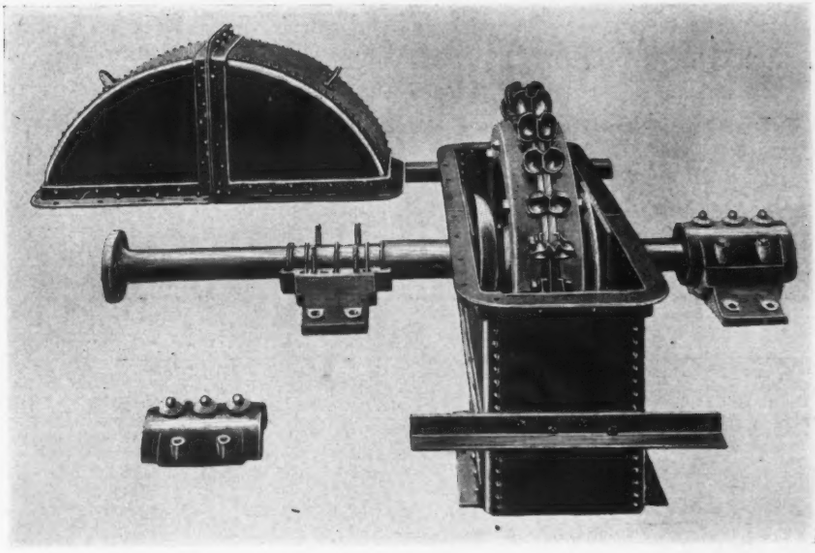
127 Main St., San Francisco 143 Liberty Street, N. Y.

Abner Doble Company

MANUFACTURERS AND HYDRAULIC ENGINEERS

Established 1850

High Class Work a Specialty



600 HORSE-POWER WATER WHEEL UNIT AT 600 REVOLUTIONS PER MINUTE UNDER 1410 FEET HEAD

Tangential Water Wheels for Electric, Mining and Other Purposes

Doble Water Wheels Lead All Others in Efficiency and Durability As Shown by Comparative Tests

Fremont and Howard Streets, San Francisco

Write for particulars.

Worthington Pumping Engines and Hydraulic Machinery

HENRY R. WORTHINGTON

Electric and Power **PUMPS** Pumping machinery for all duties

OFFICES:

New York, Boston, Philadelphia, St. Louis, Chicago, Cleveland, Indianapolis, San Francisco, London, Paris, Berlin, Vienna, Amsterdam, Brussels.

Hydraulic Works at Brooklyn, N. Y. and Elizabethport, N. J.

PACIFIC COAST BRANCH OFFICE: 132-134 FIRST STREET, SAN FRANCISCO

Telephone, MAIN 5680 Address all communications to HENRY R. WORTHINGTON

LOCAL AGENTS: Moran Bros. & Co., Seattle : Tatum & Bowen, Portland : Baker Iron Works, Los Angeles

BUYERS' DIRECTORY.

Aluminum
Pittsburg Reduction Company.

Arc Lamps
California Electrical Works.
General Electric Company.
Westinghouse Electric & Manufacturing Co.

Attorney-at-Law
Medina, Frank P.

Batteries
California Electrical Works.
Electric Storage Battery Co., The
Sloane, Chas. F.

Boiler Compounds
Crosscup, I. O.
Dearborn Drug and Chemical Works.

Carbons
Sloane, Chas. F.

Chemicals
Dearborn Drug and Chemical Works.

Dynamos and Motors
Bullock Electric Manufacturing Company.
California Electrical Works.
Crocker-Wheeler Company.
General Electric Company.
Sloane, Chas. F.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Electrical Supplies
California Electrical Works.
General Electric Company.
Joseph Dixon Crucible Company.
Sloane, Chas. F.
Westinghouse Electric & Manufacturing Co.
Electric Storage Battery Co.

Educational
Heald's Business College.
Van der Naillen School of Engineering.

Engineers
Bates, Frank H.
Benjamin, E. H.
Century Electric Co.
Cobb, Edward S.
Doble, Robert McF.
Hall, Leon M.
Hunt, A. M.
Meredith, Wynn
Ridley, A. E. Brooke.
Westinghouse, Church, Kerr & Co.

Gas Engines
Westinghouse, Church, Kerr & Co.

Gas Works Builders
Western Gas Construction Company.

Governors
Lombard Governor Co., The

Instruments
California Electrical Works.
General Electric Company.
Stanley Electric Manufacturing Company.
Weston Electrical Instrument Company.
Westinghouse, Church, Kerr & Co.

Incandescent Lamps
California Electrical Works.
California Incandescent Lamp Co.
General Electric Company.
Sloane, Chas. F.
Westinghouse Electric & Manufacturing Co.

Insulating Compound
New York Insulated Wire Company.
Paraffine Paint Company.

Line Materials
Knowles, C. S.
Locke, Fred M.
Sloane, Chas. F.

Pull Boards
Crouse-Hinds Electric Co.

Poles, Cross Arms and Pins
Carter & Co., Geo. E.
Hardwood Planing Mill Co.
Union Lumber Company.

Power Transmission
Bullock Electric Manufacturing Company.
General Electric Company.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Pipe
National Tube Company.

Pumps
Jackson Machine Works, Byron.
Moore & Co., Chas. C.
Worthington, Henry R.

Railway Supplies
General Electric Company.
Sloane, Chas. F.

Steam Boilers
Babcock & Wilcox Company.
Jackson Machine Works, Byron.
Oakland Iron Works.

Steam Engines
Ide & Sons, A. L.
Jackson Machine Works, Byron.
Moore & Co., Chas. C.
Oakland Iron Works.
Westinghouse Machine Company.

Switches—knife
Crouse-Hinds Electric Co.

Telephones
California Electrical Works.

Transformers
General Electric Company.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Water Wheels
Doble Company, Abner.
Knight & Company.
Oakland Iron Works.
Pelton Water Wheel Company, The.

Wires and Cables
California Electrical Works.
New York Insulated Wire Company.
Okonite Co., Ltd., The.
Pacific Electrical Works.
Pittsburg Reduction Company.
Standard Underground Cable Co.

P.&S. PORCELAIN GOODS

[redacted] BEAR INSPECTION

There are none better

San Francisco Deliveries **Right Prices**

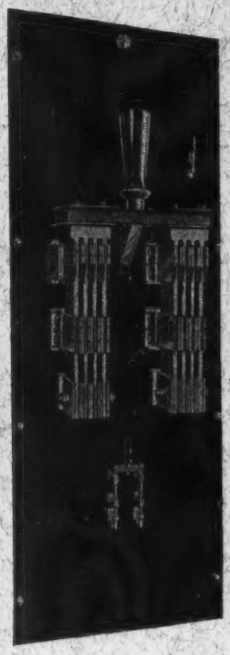
Pass & Seymour, Inc.

Solvay, New York

THE CHAS. F. SLOANE CO.,

Pacific Coast Sales Agents Mills Bldg, SAN FRANCISCO

"CROUSE-HINDS"



SWITCHES

BIG AND LITTLE

BUT ALWAYS

High-Grade

Cut shows 7500 ampere KNIFE SWITCH on 6'6" slab. Operated by one man. . . . . .

CROUSE-HINDS

Electric Co.

Main Office and Works: Syracuse, N. Y.

THE CHAS. F. SLOANE CO.

Pacific Coast Sales Agents

Mills Building SAN FRANCISCO

SAN FRANCISCO DELIVERIES ARE INSTANT DELIVERIES

Immediate Shipments from San Francisco stock are made on Orders for the Products of

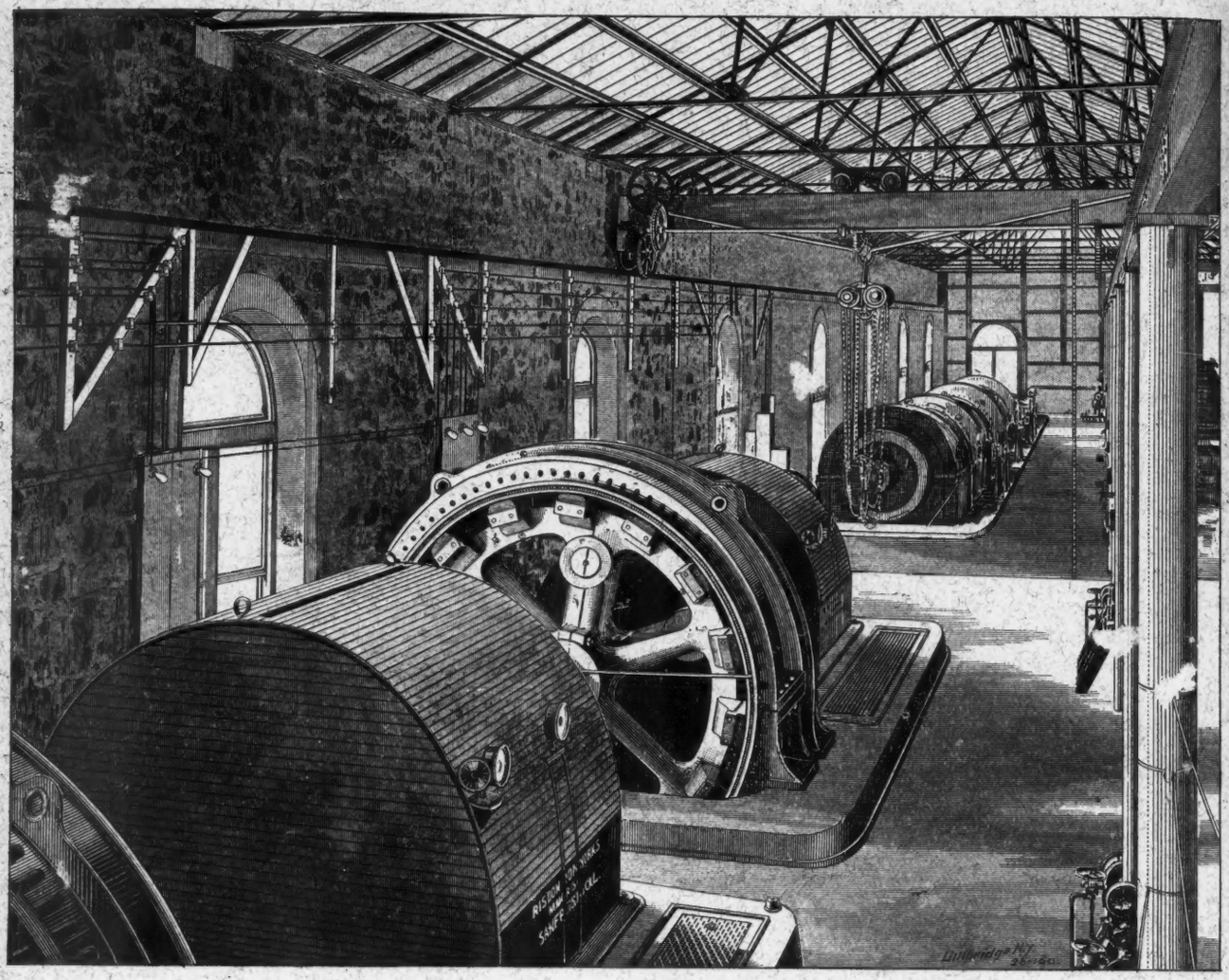
CROUSE-HINDS ELECTRIC CO.,	Knife Switches
PASS & SEYMOUR	Porcelain Goods
HEMINGRAY GLASS CO.,	Provo-type Insulators
STANDARD UNDERGROUND CABLE CO.,	Wires and Cables
HART & HEGEMAN MANUFACTURING CO.,	Flush Switches
SAFETY ARMORITE CONDUIT CO.,	Iron Armored Conduit
PACIFIC ELECTRICAL WORKS	Weatherproof and Magnet Wires

THE CHAS. F. SLOANE CO.

Pacific Coast Sales Agents : : Mills Building, San Francisco

THE engraving is from a pen and ink drawing of the Bay Counties Colgate Power House. The familiar form of the S. K. C. Inductor Generators is at once recognized.

The electrical equipment of the station and of the whole Bay Counties system consists practically exclusively of apparatus of the S. K. C. System.



The same is true of the other great California long distance Transmission system (The Standard Electric Company). Together, the aggregate rated capacity of S. K. C. Generators and Motors, either installed or in course of construction for these two great systems amounts to **46,240** kilowatts.

S. K. C. Transformers, Switchboard Apparatus, Etc., predominate to a like degree, and reference to any authentic description of the installations referred to will so corroborate.

S. K. C. Apparatus is unequalled
for simplicity and reliability.

Stanley Electric Manufacturing Company, Pittsfield, Mass.

JNO. MARTIN & CO. PACIFIC COAST AGENTS

PIONEER BUILDING, SEATTLE, WASH. 31-33 NEW MONTGOMERY STREET, SAN FRANCISCO, CAL.